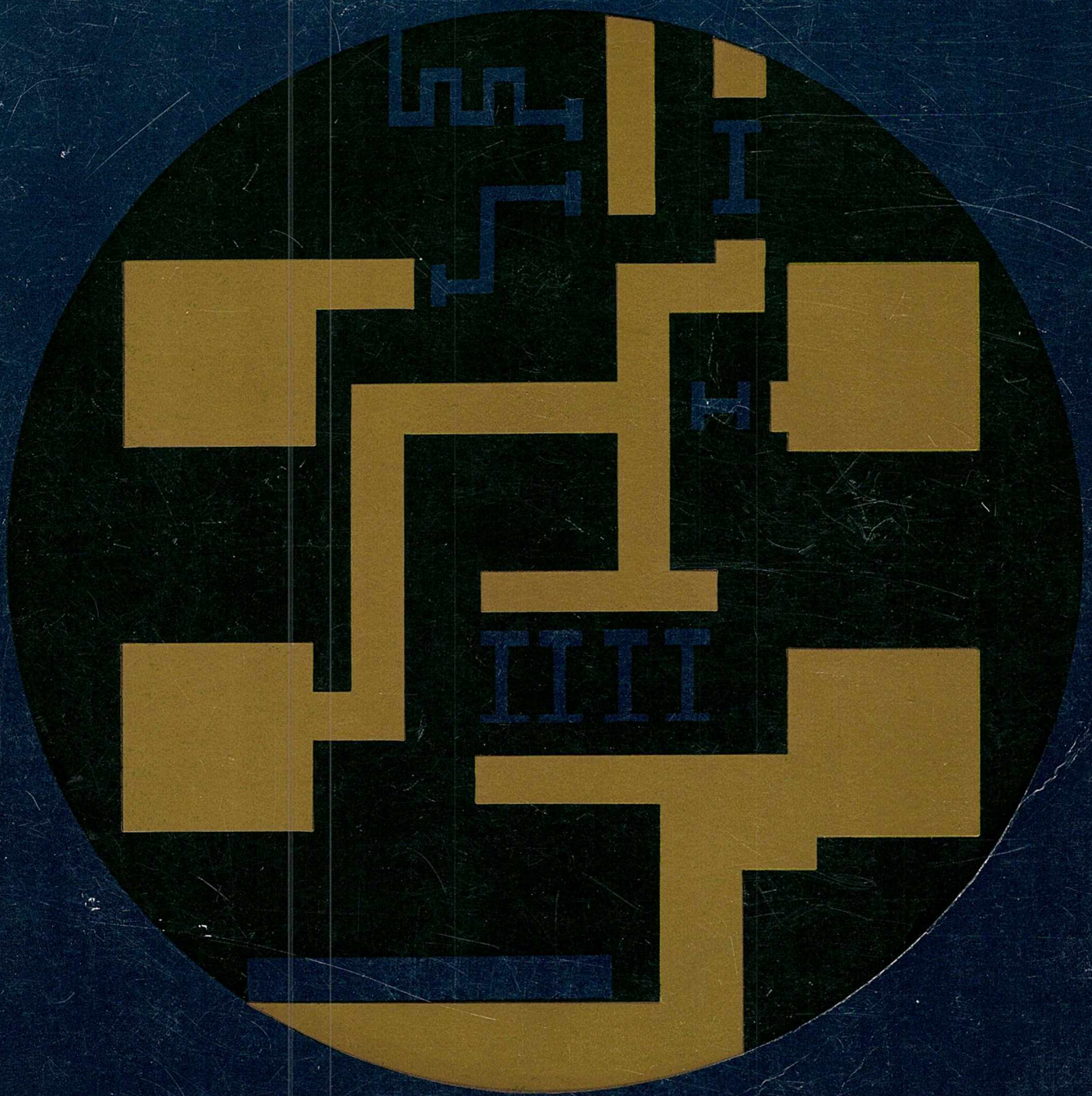
Electronics Drafting Workbook



KIRSHNER & STONE

No. 2-70

LYMAN HALL HIGH SCHOOL

WALLINGFORD, CONNECTICUT

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ELECTRONICS DRAFTING WORKBOOK

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McGRAW-HILL BOOK COMPANY

New York St. Louis San Francisco
London Toronto Sydney

Equipment Used in Electronics Drafting

The equipment used in electronics drafting is, for the most part, the same as that used in mechanical drafting, such as:

Drawing board
24″ T square
45°/90° triangle
30°/60° triangle
Compass
X-acto knife
Protractor
Scale (12″ preferred with both
1/32″ and 1/50″ increments)
French curve
Erasing shield
Dusting brush
Drafting (or masking) tape
Ruby drafting eraser
Drafting pencils (H, 2H, and 4H)
or automatic preferred
Sandpaper pad or file

The above list is the usual equipment required for mechanical drafting, which is the same as required for electronics drafting. The student having these items but in different sizes need not purchase any new equipment other than an electronics template.

Electronics template MIL-STD-15-1A

ELECTRONICS DRAFTING WORKBOOK

34863

4 5 6 7 8 9 10 BABA 7 5 4 3 2 1 0 6 9

We respectfully dedicate this book to our families and our friends, and to the advancement of technical education.

Preface

Electronics Drafting Workbook was written to give students a realistic feel for electronics drafting and to supplement the resources of the employed draftsman by means of the lesson samples and, especially, the appendixes.

The book is written for the student between high school and college, say, the last two years of high school or the first two years of college. It can also be used easily by adult education programs as well as by correspondence or home study students. The material presented is largely based on the electronics drafting course taught at Los Angeles Valley College since 1959 for both day and evening classes, as well as at the Adult Occupational Training Center, Woodland Hills, California, with a great deal of success. The course at Los Angeles Valley College is credit-transferable to California Polytechnic Institute (which is fully accredited) and meets the electronics drafting requirements for the electronics engineer's degree.

The sequence of lessons was designed with these considerations in mind:

1. To progress from a simpler, or more familiar, kind of drawing to one that is slightly more complex. Therefore it would be well to follow the exercises in order where feasible.
2. To start the student out immediately doing *electronically related* drafting, without spending too much time on conventional mechanical drafting review, and to develop a consecutive interest in electronics drafting concepts.
3. To present the most frequently used types of drawings first and infrequently used types of drawings last (i.e., based on the experiences of most beginning draftsmen).
4. To culminate the various ideas in a project at the end of the semester, or at least to indicate how this can be done.

The basic technique of instruction used here is to present a little theory and an exercise on *each* page with a step-by-step "learn by doing" approach. Another technique is to develop the habit of looking up *new* information (in the appendix, catalogs, etc.) and checking back *old* information (from previous exercises, drawings, etc.).

The authors wish to thank the many people who contributed to the preparation of this book. In particular, we would like to mention:

ITT Federal Laboratories, San Fernando, California

Harold Emus, senior member of the technical staff of the ITT Federal Laboratories, San Fernando, California

Carlos Miller, Director of Product Operations, ITT Federal Laboratories, San Fernando, California

The General Electric Company, for the FM Tuner schematic diagram (page 27) and the Power Supply schematic diagram (page 55)

RCA, for the color and black and white TV Receiver block diagram (page 20)

The Zenith Electric Co. for the color TV block diagram (page 22)

We would also like to express sincere appreciation to the following firms which contributed to, and are represented in, our appendixes:

Arco Electronics, Inc., Alpha Wire Corp., General Electric Company, Grayhill, Inc., Herman H. Smith, Inc., Hughes Semiconductors, Littelfuse Incorporated, Ohmite Mfg. Co., Texas Instruments Incorporated, Triad Transformer Corporation, USECO, Vitramon, Inc., Westinghouse Electric Corporation, and Department of Defense Military Standards.

Cyrus Kirshner
Kurt Stone

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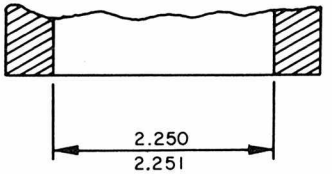
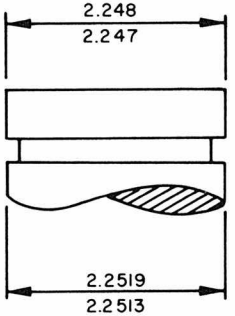
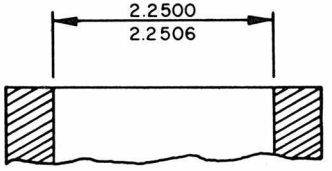
Electromechanical lettering need not be artistic, but it should be neat and legible.	Copy the **notes** taken from column 1 started below, going from bottom to top.	Copy in column 4 the entries of column 3 using ⅛" high vertical lettering.
NOTES: 1) ELECTRONICS LETTERING IS LARGELY DONE FREEHAND ON VELLUM WITH OR AGAINST A 1/8 OR 1/10 GRID BACKGROUND. 2) THE LETTERING CAN BE EITHER VERTICAL OR *INCLINED*. 3) THE STUDENT SHOULD LEARN BOTH STYLES. HOWEVER, IT IS EASIER TO LEARN VERTICAL LETTERING FIRST AND *INCLINED LETTERING 2ND*, RATHER THAN VICE VERSA. 4) PRACTICE DEVELOPS TECHNIQUE.	2) THE LETTERING 1) ELECTRONICS LET- NOTES:	$2\frac{1}{2}$ $3\frac{3}{4}$ $4\frac{5}{64}$ $5\frac{7}{64}$ $6\frac{7}{8}$ $7\frac{9}{32}$ $8\frac{9}{16}$ $9\frac{1}{10}$ $5.110^{\pm.005}$ DIA. $6.120^{\pm.002}_{.000}$ TOL. = TOLERANCE FRAC. = ± 1/64; X° = ± 1/2° .XX = ± .03; .XXX = ± .010  2.250 2.251 CLEARANCE FIT  2.248 2.247 2.2519 2.2513 INTERFERENCE FIT  2.2500 2.2506

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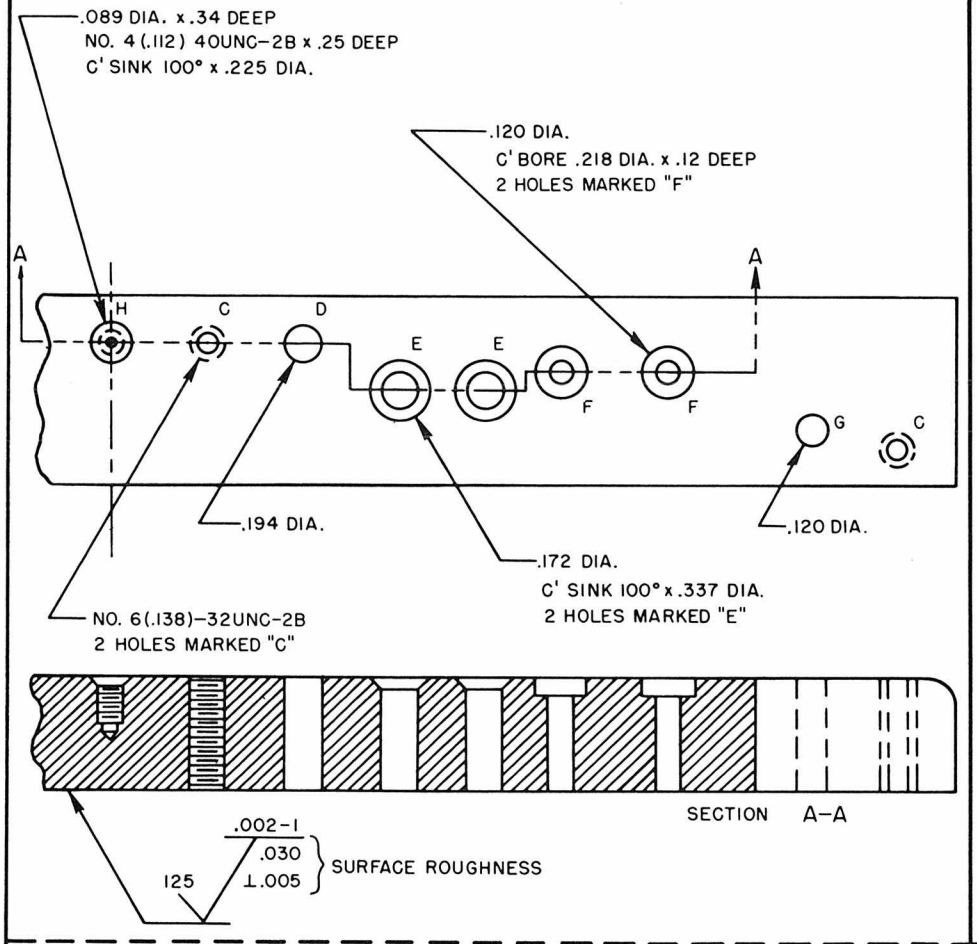
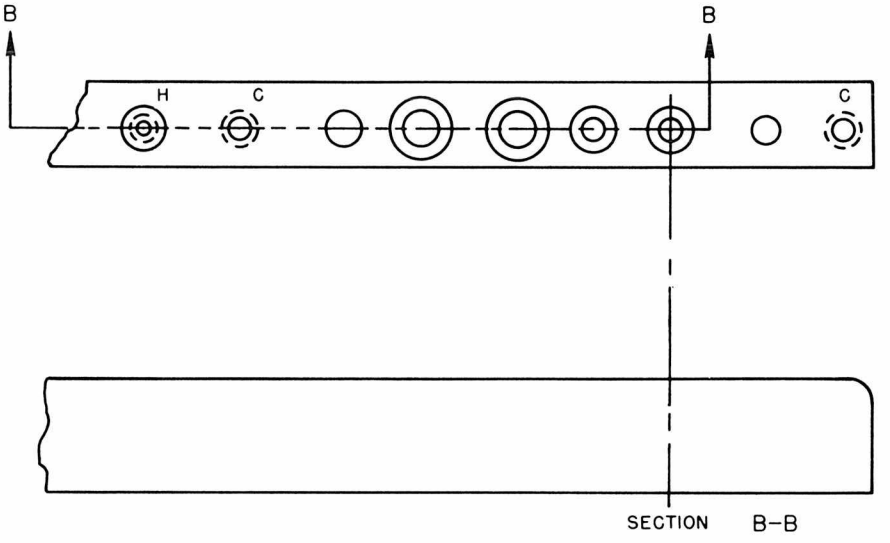


ELECTROMECHANICAL LETTERING

Copy the callouts shown at the left on the diagram below. Complete section B-B similar to section A-A. Use ⅛" lettering.



MAT'L: 2024-T4 ALUM. AL. (BAR) PER SPEC QQ-A-268
FINISH: ALODINE PER MIL-C-5541

MAT'L: #303 CRES (BAR) PER MIL-S-7720
FINISH: PASSIVATE (CRES = CORROS. RESIST. STEEL)

MAT'L: BRASS, HALF HARD (SHEET) PER QQ-B-613
FINISH: CAD. PLATE PER QQ-P-416 TYPE 1

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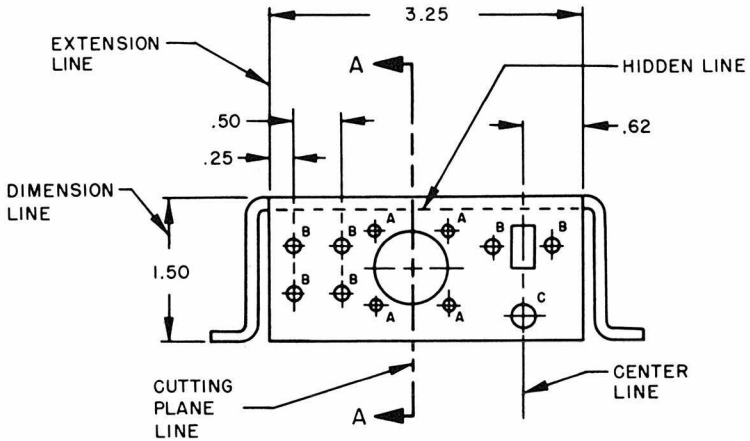
DIMENSIONING AND LINE WEIGHTS

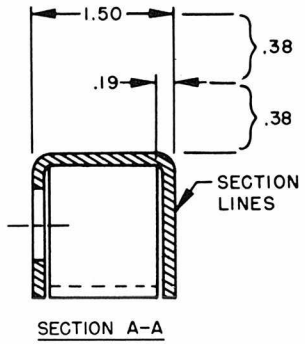
VISIBLE LINE: thick (H lead)
For outline and cutting planes.

HIDDEN LINE: medium (2H lead)

SECTION LINE: thin (4H lead)
For center lines, section, dimension, extension, and phantom lines.

With a little practice, all lines mentioned above can be made with a 2H lead by varying pressure and relining.



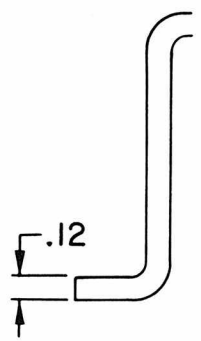


PANEL FRONT VIEW

Exercise. The panel above is only partially **dimensioned** at half scale. Redraw the panel full scale and dimension it completely. Omit section A-A.

Hint: The missing dimensions will have to be found by **scaling** the half scale drawing above and **multiplying by 2.**

Use your template for all holes and radii.



HOLE DIM. CHART	
LETTER	HOLE DIA.
A	.125
B	.188
C	.250
D	.750

TITLE					DWG. NO.
MECHANICAL DRAFTING REVIEW – DIMENSIONING, DOUBLE ARROW					MDR-2
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DIMENSIONING FROM A DATUM

On sheet 1 you used the **conventional double arrow and dimension line** method, shown again in Fig. 1. If space is limited, **arrowless dimensioning from a datum** is preferred, as shown in Fig. 2.

Avoid dimensioning to hidden lines. Dimension another view. A **sectional view** may be necessary.

Use **decimal dimensioning** for all work.

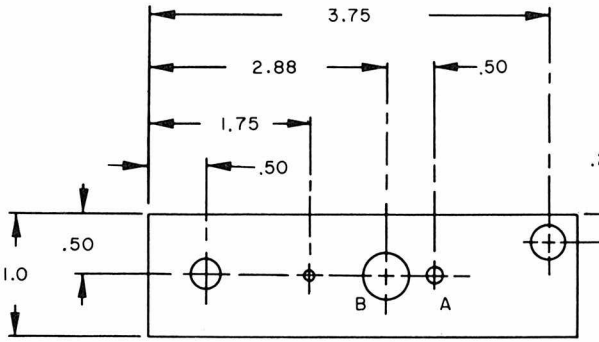


Fig. 1

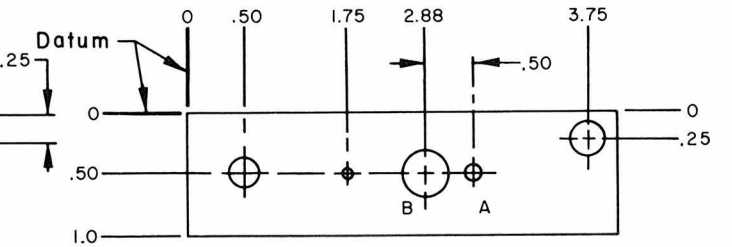
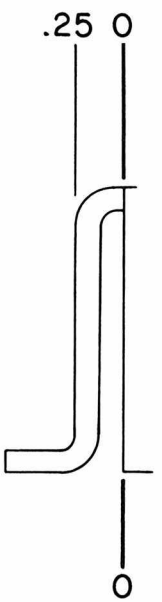


Fig. 2

Note: Location of hole A is critical to hole B; therefore the dimension is direct to hole B and not to the datum.

Exercise. Redraw the front and section A-A of the panel on sheet 1 using the **datum dimensioning** method, full scale.



TITLE	MECHANICAL DRAFTING REVIEW – DIMENSIONING, DATUM				DWG. NO. MDR-2	
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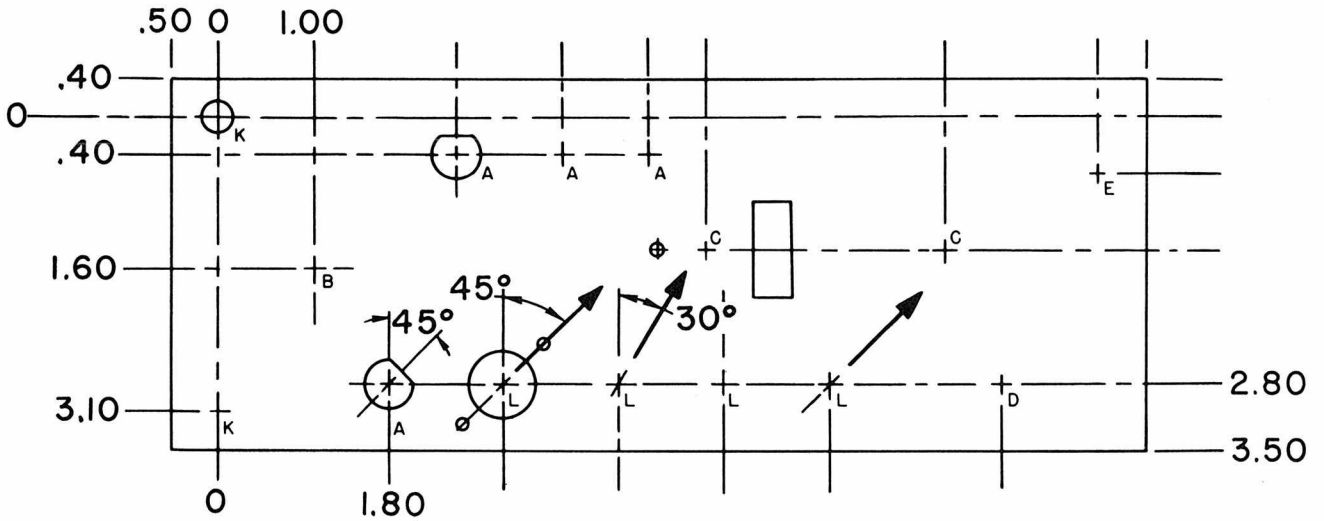
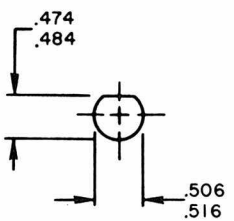
DIMENSIONING

The drawing below is a typical partially dimensioned example showing the use of standard hole layouts.

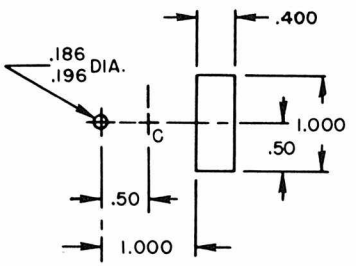
Exercise. Dimension the missing hole locations and draw the hole pattern properly in place. Use the **datum dimensioning method (arrowless dimensioning).** Scale: half size. Lettering ⅛".



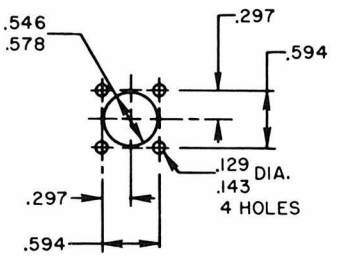
HOLE	DESCRIPTION
A	SEE DETAIL 1
B	1.000 DIA.
C	SEE DETAIL 2
D	SEE DETAIL 3
E	SEE DETAIL 4
K	.307 / .318 DIA.
L	SEE DETAIL 5



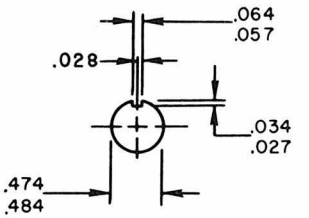
DETAIL 1
A



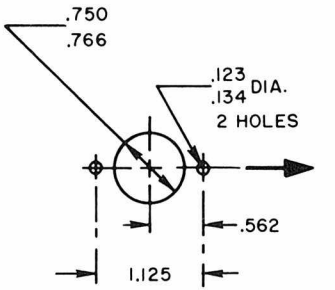
DETAIL 2
C



DETAIL 3
D



DETAIL 4
E



DETAIL 5
L

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MECHANICAL DRAFTING REVIEW – DIMENSIONING		MDR-2

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				HALF SIZE	SHEET 3 OF 3	5

TAPPED HOLES AND CLEARANCE HOLES

When a **part** has a feature, such as a tapped hole, which fixes a clamping screw or stud, the other part will have a **clearance hole** (see Fig. 1). Use the formulas in Appendix D, Single and Multiple Hole Mounting.

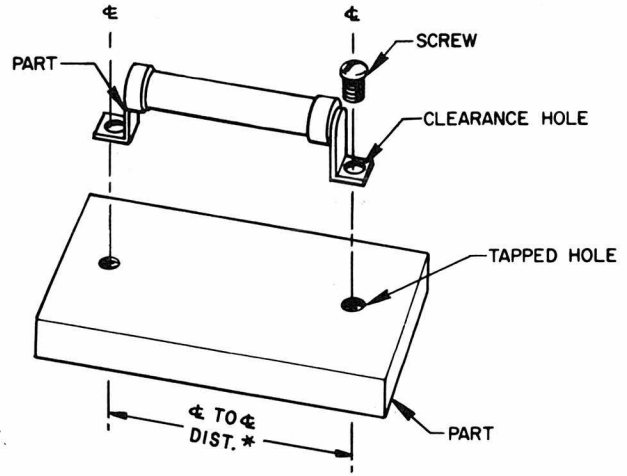

Fig. 1

Example. What is the **clearance hole diameter** of a single #10-32 binding head screw?

Answer. See Appendix D. Single Hole Dia. = .194. To this one must add the **tolerance,** which also is found in Appendix D under Standard Drilled Hole Tolerance. Since the hole is .194 Dia., look in the column opposite .126 through .250. The tolerance is $^{+.005}_{-.001}$ Therefore the correct way to specify the hole callout is .194 $^{+.005}_{-.001}$ DIA.

For **multiple holes** use the formulas in Appendix D (see Multiple Hole Pattern). These formulas will be helpful in future work and design in the industry.

Study Appendix D examples 1, 2, and 3, then proceed to the exercise on the right.

*℄ = center line

Exercise. What is the correct clearance hole diameter and tolerance of these single binding head screws

#4-40 =

#¼-20 =

What is the correct clearance hole diameter, C'sink diameter, and tolerance of these flat head screws (82°)

#6-32 =

#10-32 =

Exercise. What should the **clearance hole diameter** and **tolerance** be in the part shown in Fig. 2? Show how you arrived at the answer. Use the formulas in Appendix D.

Answer

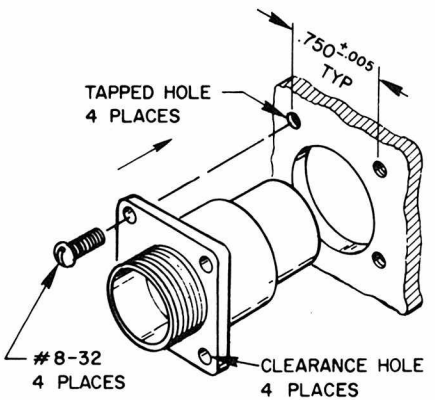

Fig. 2

TITLE	MECHANICAL DRAFTING REVIEW – CLEARANCE HOLE ON TAPPED				DWG. NO. MDR-3	
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SCREW CLEARANCE HOLES

When a part is held by a **screw** and **nut** or fasteners which have the same basic clearance between **hole** and **screw** (see Fig. 1) use the same formulas shown in Appendix D. The same formulas will apply in this case *except that the last part is divided by 2.* Remember, the difference in formula depends on whether clearance holes (only) or tapped holes are being used.

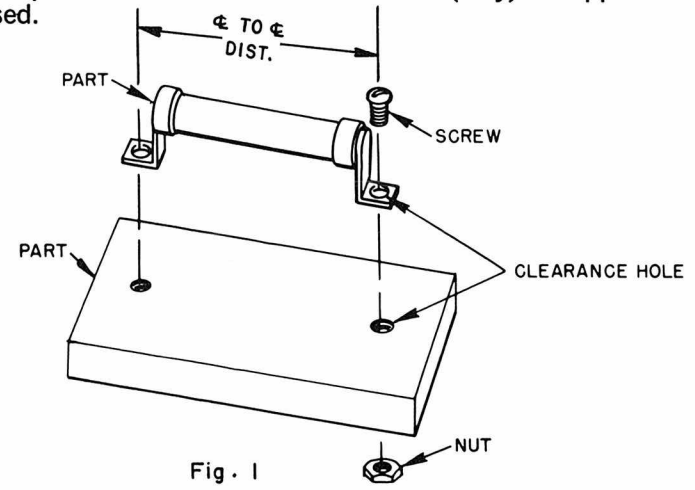

Fig. 1

Example. What should be the hole diameter of the sample shown in Fig. 1 if the two screws used are #6-32 binding head. (℄ to℄ is ±.010)?

The formula for the 2-hole (tapped) pattern in appendix D is: $D = d + 2t$. In this case (clearance hole on clearance hole) the last term is divided by 2 and reads:

$$D = d + \frac{2t}{2}$$

$$= .138 + \frac{2\,(.010)}{2}$$

$$= .138 + .010 = .148$$

The clearance hole will be (see drill sizes, Appendix E).

$$.149\ ^{+.005}_{-.001}\ \text{DIA.}$$

2 HOLES

Exercise 1. What should be the clearance hole diameter and tolerance of the parts shown in Fig. 2?

Show how you arrived at the answer. Use the formulas in Appendix D.

Answer

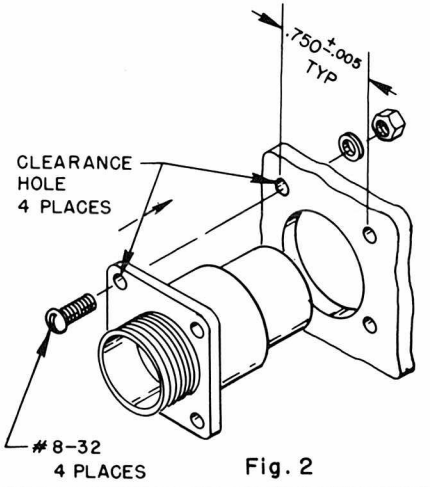

Fig. 2

Compare the answer above with previous exercise on sheet 1 (Fig. 2).

CLEARANCE ON TAPPED _____

CLEARANCE ON CLEARANCE _____

Exercise 2. What should be the clearance hole diameter and tolerance in Fig. 3? (℄ to℄ is ±.010)

Answer

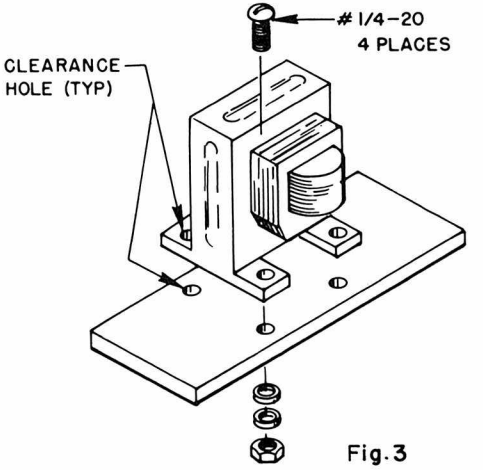

Fig. 3

TITLE MECHANICAL DRAFTING REVIEW-CLEARANCE HOLE ON CLEARANCE					DWG. NO. MDR-3	
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ELECTRO-GEOMETRIC CONSTRUCTIONS

Step-by-step **geometric construction technique** is shown in the accompanying tables and corresponding diagrams.

	GEOMETRIC CONSTRUCTION	SAMPLE USE
1	HEXAGON	HEX NUT
2	LINE DIVIDING	EQUAL SPACING OF HOLES
3	CONCENTRIC ARCS	SHEET METAL BENDS
4	LINE AND ARC TANGENTS	CABLE CLAMPS
5	TANGENT ARCS	POTENTIOMETER KNOB

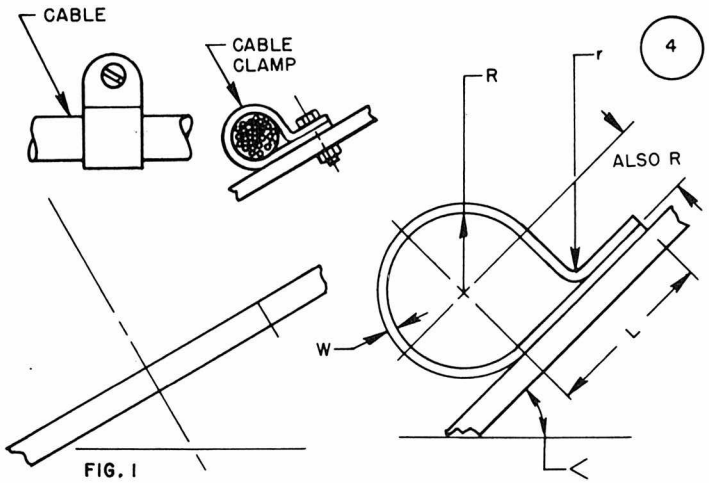
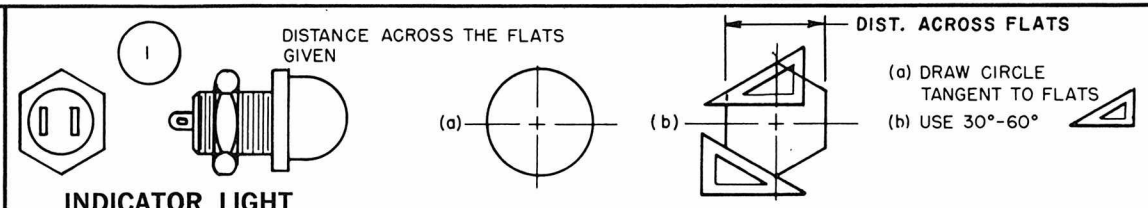


FIG. 1

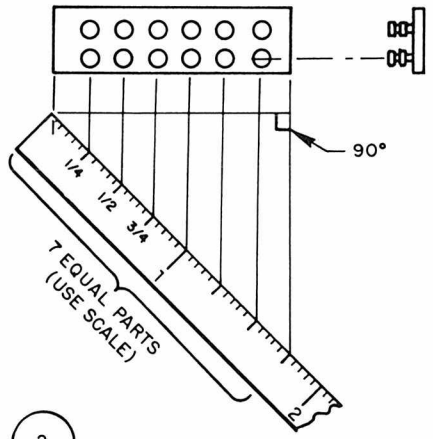
Exercise. On the started illustration above (Fig. 1) lay out a **clamp** on a **clamp support.** Given:

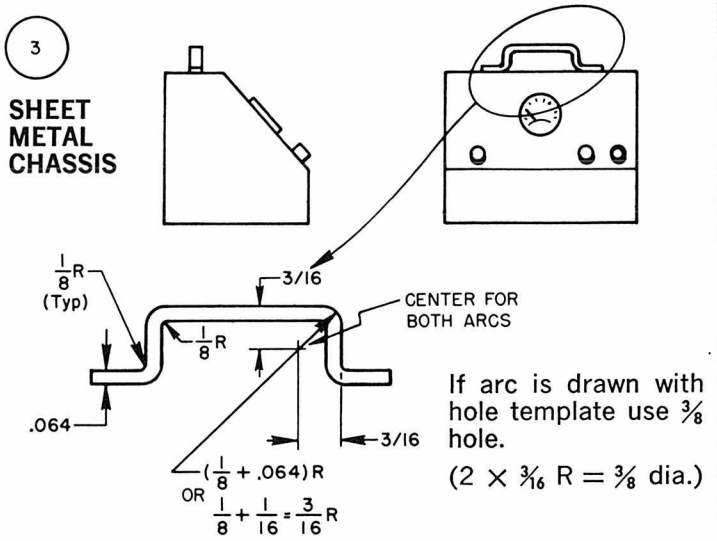
$R = \frac{5}{16}$, $r = \frac{1}{8}$, $L = 1.0$
$W = \frac{1}{8}$, $< = 30°$



INDICATOR LIGHT

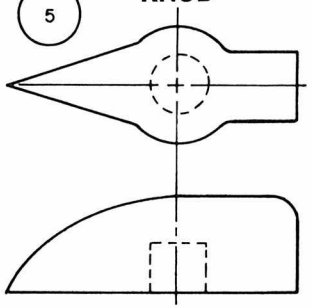
TERMINAL BOARD





If arc is drawn with hole template use $\frac{3}{8}$ hole.
($2 \times \frac{3}{16} R = \frac{3}{8}$ dia.)

KNOB

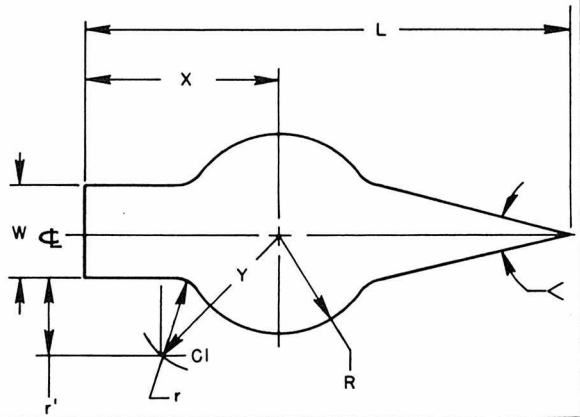


The knob shown is a typical example of **tangents and arcs** construction.

L, X, W, R, r, and < are given. The problem is to **construct tangent arcs** from C1.

$r' = r$
Draw r' || to ℄
$Y = R + r$

Draw arc Y. The intersection of Y and r' is the center (C1) for arc r.



TITLE					DWG. NO.
MECHANICAL DRAFTING REVIEW–GEOMETRIC CONSTRUCTION					MDR-4
NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 2 / PAGE 8

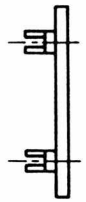
Exercises. These are typical Electro-geometric construction exercises. Refer to sheet 1 for all exercises.

Draw a **hexagon** similar to the one shown on sheet 1, item 1, whose distance across the flats is 1.0″.

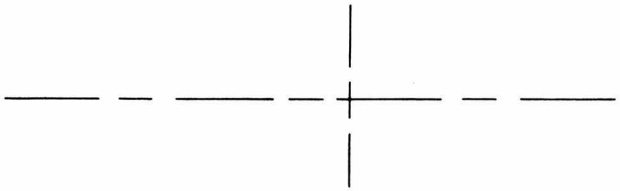
Draw a **terminal board** similar to the one shown on sheet 1, item 2, whose dimensions are 2 x 1.0 x 1/16 with eight pairs of terminals forming two equally spaced rows.

Hint: Including edge distance, divide the board into nine equal parts.

Show your method of development by leaving in place all light construction lines.



Draw a **knob** similar to the one shown on sheet 1, item 5, whose dimensions are:
L = 2½, x = 1.0, R = ½
W = ½, r = ⅜, < = 30°
Construct the upper half of the knob by the method of **tangents and arcs,** then use your template to draw the lower half.

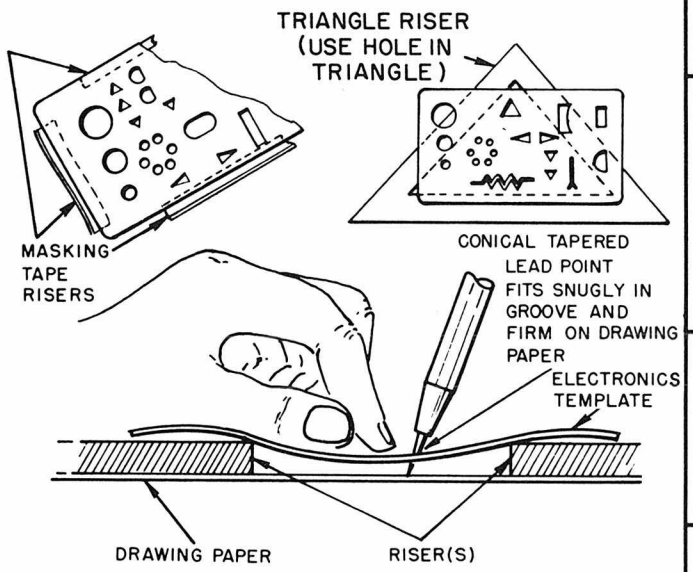


Draw a sheet-metal chassis **handle** similar to the one shown on sheet 1, item 3, whose dimensions are: ⅛ thick, 3/16 inside bend radius. The handle is ¾ high, 3.0 overall length with a 1¾ inside grip length. Construct the right half of the handle with concentric arcs and the left half with your template.

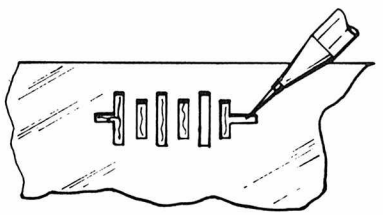
Draw a **cable clamp** similar to the one shown on sheet 1, item 4, for a cable 1.0″ diameter on a clamp support inclined 30°.
W = ⅛, L = 1¼, r = ⅛.
Show construction lines.

TITLE					DWG. NO.
MECHANICAL DRAFTING REVIEW–GEOMETRIC CONSTRUCTION					MDR-4
NAME	DATE	COURSE	GRADE	SCALE	SHEET 2 OF 2 / PAGE 9

TEMPLATE PRACTICE



Theory. Template grooves are generally too wide for use without risers. The battery symbol shown comes out wobbly if the lead point does not fit snugly in the groove. No single electronics template has **all** the symbols. If your template doesn't have a needed symbol, draw it proportionately to those shown in Appendix A.



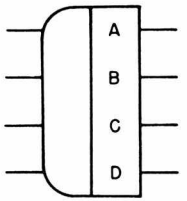
COMPONENT NAME	LETTER SYMBOL	**Instruction:** Use your template(s) to fill in the spaces below.
		SCHEMATIC SYMBOL
AMPLIFIER	AR	Draw three or more schematic symbols per line.
ANTENNA	E	
BATTERY	BT	(ONE CELL) (MULTICELL)
CAPACITORS (fixed) (variable)	C	(GENERAL) (POLARIZED OR ELECTROLYTIC) (GEN.) (MECH. LINKED)

TITLE **ELECTRONICS SYMBOLS** – ELECTRONICS TEMPLATE FAMILIARIZATION

DWG. NO. **SYM-1**

NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 3	PAGE 10

Fill in the blank spaces as in the last exercise by referring to Appendix A. Use either vertical or inclined 1/8″ or 1/10″ uppercase lettering (three symbols per line).

COMPONENT NAME	LET. SYM.	SCHEMATIC SYMBOL	COMPONENT NAME	LET. SYM.	SCHEMATIC SYMBOL
					
SEMICONDUC-TOR, RECTIFIER DIODE					
	Y		INCANDESCENT FILAMENT		
	TB			LS	
			5-CONDUCTOR CABLE (SHIELD GROUNDED)		

TITLE		DWG. NO.	
ELECTRONICS SYMBOLS-ELECTRONICS TEMPLATE FAMILIARIZATION		SYM-1	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 2 OF 3	PAGE 11

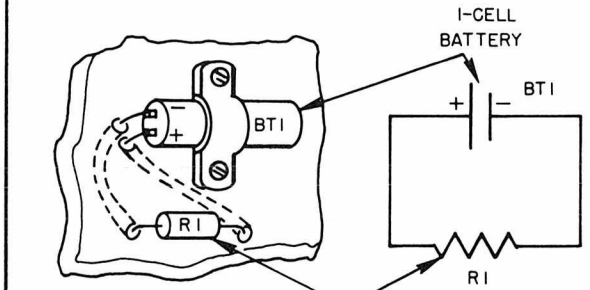
Choose nine new symbols from Appendix A which were not drawn in the last two exercises and complete the chart below, using ⅛" lettering. (Lightly lay out symmetrical spacing first.)

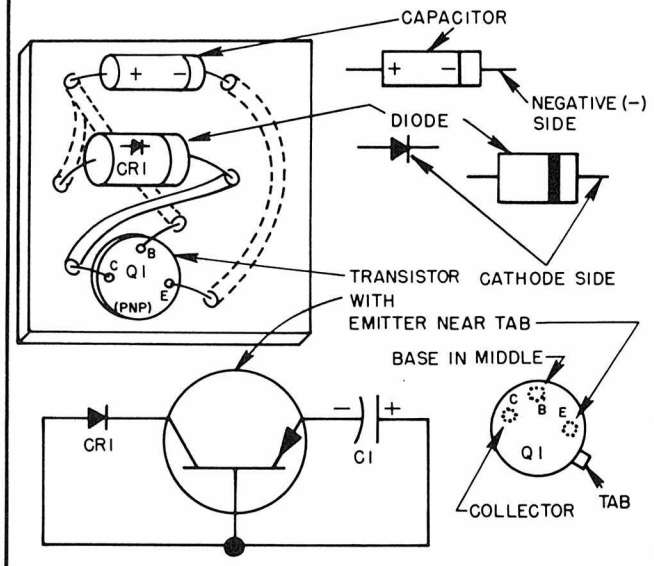
COMPONENT NAME	REF. DESIG.	SCHEMATIC SYMBOLS

TITLE	ELECTRONICS SYMBOLS–ELECTRONICS TEMPLATE FAMILIARIZATION				DWG. NO. SYM-1	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 3 OF 3	PAGE 12

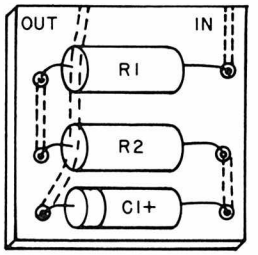
SYMBOL HOOKUP PRACTICE

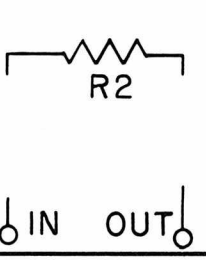
Study the printed circuit (PC) hookups shown below with their corresponding symbol representations (circuits). Complete the circuits in columns 2 and 3.

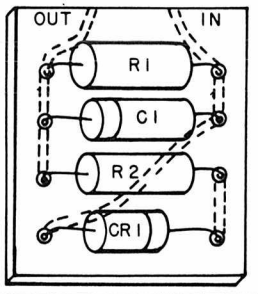


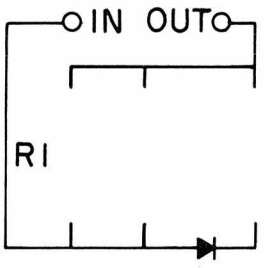


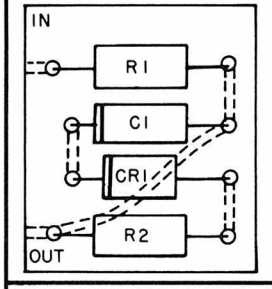
COLUMN 2

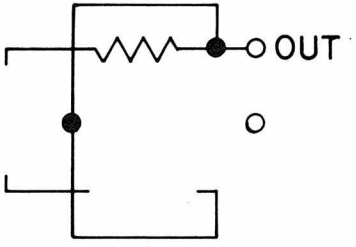


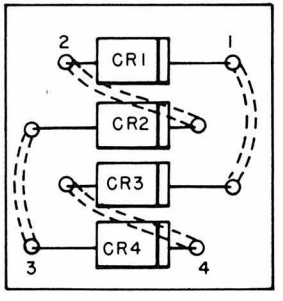


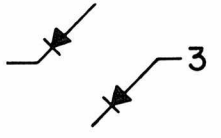




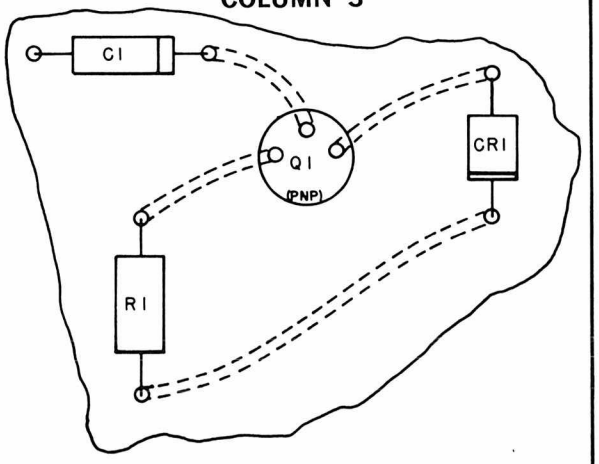


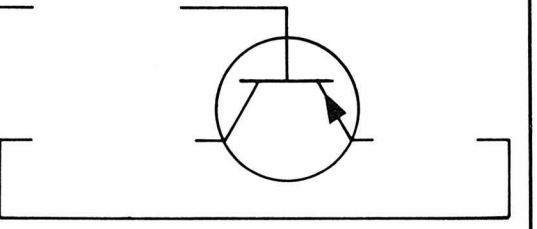


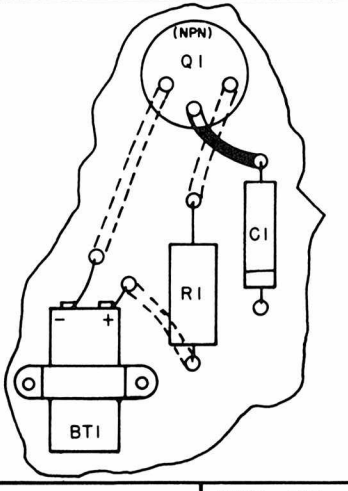


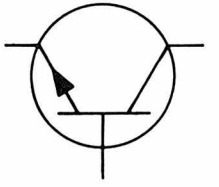


COLUMN 3









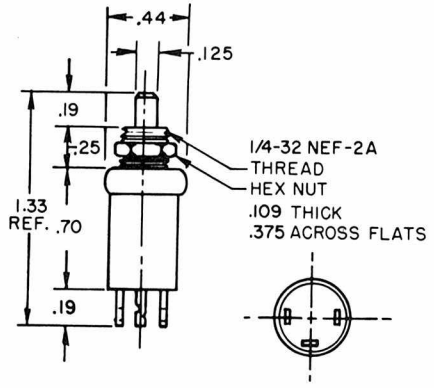
TITLE					DWG. NO.
ELECTRONICS SYMBOLS - SYMBOL HOOK-UP PRACTICE					SYM-2
NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 1 / PAGE 13

INTRODUCTION: COMPONENT OUTLINE DRAWINGS

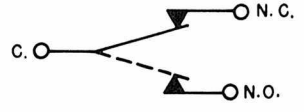
An **outline drawing,** as shown below, describes the contour and overall dimensions of a component. These drawings are usually associated with "specification control" or "purchase control" drawings (the three names are often used interchangeably). The "spec" control drawing consists of an outline drawing plus other information which specifies the necessary prerequisites for use of the component. The drawing generally includes manufacturer's name, model number, component name and symbol plus a list of specifications. This type of drawing is regarded as the principal document in a component purchasing contract.

EXAMPLE

COMPONENT OUTLINE



COMPONENT SYMBOL



SINGLE POLE, DOUBLE THROW SWITCH

RATING:

Rated: to make and break ¼ ampere, 115 VAC resistive.
Contact Resistance: .010 ohms maximum initial measured at 2 VDC, 100 ma. After 250,000 operations .010 ohms typical; .020 ohms maximum.
Insulation Resistance: 100,000 megohms measured at 100 VDC, 60% to 70% relative humidity.
Dielectric Strength: 1500 VAC approximate at sea level.
Life Expectancy: 250,000 operations at rated load.

CONSTRUCTION:

Single pole double throw
Wiping contacts
Button Travel: .187" approximately.
Overtravel: .062" approximately.
Actuating Force: 16 oz. approximately to bottom button.
Mounting Hole: 17/64" dia.

MANUFACTURER:
GRAYHILL INC.

Exercise. Draw an **outline** of a ½AMP 125V fuse, full size. Show all dimensions, symbol, reference designation, manufacturer's name, and component part number. Information may be found in Appendix B, page 82.

COMPONENT
OUTLINE

COMPONENT SYMBOL 

REF. DESIGNATION _____

MANUFACTURER _____

PART NO. _____

Exercise. Give the following Mil Type Designation No. of 1.2K, 2.4K, 15K, 56K, 390K, 6.2MEG. ½WATT ±5% resistor (RC20 type). Information may be found in Appendix B, page 78.

RESISTANCE IN OHMS	MIL TYPE DESIGNATION
1200	RC20GF122J

TITLE					DWG. NO.	
COMPONENT OUTLINE - INTRODUCTION					COMP-1	
NAME	DATE	COURSE	GRADE	SCALE	SHEET	PAGE
				NOTED	1 OF 2	14

SPECIFICATION CONTROL DRAWING

Complete the exercises below. All outline drawing information may be found in Appendix B.

Make an outline drawing of transistor 2N1304, 2 × size. Show (two views), all dimensions, symbol, and Manufacturer's name.

COMPONENT SYMBOL

MANUFACTURER	REF. DESIG.	COMPONENT
	Q	TRANSISTOR 2N1304

Make an outline drawing of 26.570 MC. crystal, 2 × size. Show (two views) all dimensions, symbol, reference designation, Manufacturer's name, and component number.

MANUFACTURER	REF. DESIG.	COMPONENT
		CRYSTAL

Prepare an outline drawing of the 1N617 diode (two × size).

MANUFACTURER	REF. DESIG.	COMPONENT
		DIODE 1N617

Prepare an outline drawing of the 1N2155 diode (full scale).

MANUFACTURER	REF. DESIG.	COMPONENT
		DIODE 1N2155

TITLE	DWG. NO.
COMPONENT OUTLINE – SPECIFICATION CONTROL DRAWINGS	COMP-1

NAME	DATE	COURSE	GRADE	SCALE		PAGE
				NOTED	SHEET 2 OF 2	15

A TYPICAL PROBLEM IN OUTLINE DRAWING. An engineer has given you the following list of components to be used in a packaging design:

A. RESISTOR, FIXED, COMPOSITION, ¼WATT ±5% (MIL TYPE RC07)
R1, R3: 1K; R2, R5, R7: 33K; R4, R6, R8: 22K; R9, R11: 100K; R12, R10: 1.2MEG

B. CAPACITOR, GENERAL PURPOSE, 200V (MIL TYPE CK05)
C1, C5, C7: 47pf; C2, C4, C6: 120pf; C3: 150pf; C8, C10: 470pf; C9, C11: 820pf

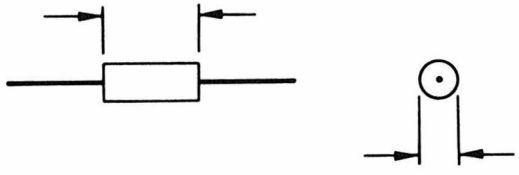
C. CAPACITOR, ELECTROLYTE, 35V, ±10% (MIL TYPE CS13)
C12, C14: 0.33MFD; C13, C15: 0.47MFD; C16, C17: 1MFD

Prepare three types of "spec control" drawings (A, B, and C) in the three columns below. The first column is almost complete, the second is just started, and the third is blank. Complete all three columns in a similar manner, using Appendix B. All drawings 2 × size.

RESISTOR — RC07 A

REF. DESIG.	RESISTANCE IN OHMS	MIL TYPE DESIGNATION
R1, R3	1000	RC07GF102J
R2, R5, R7	33K	
R4, R6, R8		

COMPONENT OUTLINE
(COMPLETE DWG. BELOW)



COMPONENT SYMBOL
(DRAW IT BELOW)

CAPACITOR — CK05 B

REF. DESIG.	CAPACITANCE IN pf	MIL TYPE DESIGNATION

COMPONENT OUTLINE

COMPONENT SYMBOL

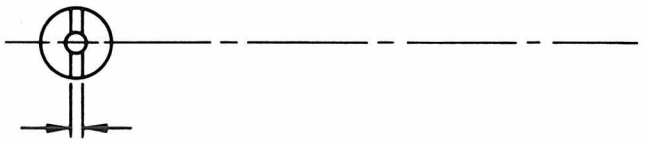
MANUFACTURER

CAPACITOR — CS13 C

TITLE	COMPONENT OUTLINE—ELECTRICAL				DWG. NO. COMP-2	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 1 OF 2	PAGE 16

A board .125″ thick requires *x* miniature-size terminals. Select the proper terminal from Appendix C and draw an outline 4 × size. Show all dimensions, manufacturer's name, and part number.

COMPONENT OUTLINE



MANUFACTURER'S NAME

COMPONENT PART NO.

Two boards require #8-32 threaded hex standoffs between them. The highest component between the boards is .47″ high. Choose the correct threaded hex standoffs from Appendix C and draw an outline 2 × size. Show all dimensions, manufacturer's name, and part number.

COMPONENT OUTLINE

MANUFACTURER'S NAME

COMPONENT PART NO.

Many types of hardware are found in **Military Standards** (**MS** or **Mil Std**) and do not require outline drawings as long as the MS number is given.

Exercise. The following hardware is necessary for a packaging design (all MS numbers are given in Appendix C):

Pan Head Screws: #4-40 NC × ¼ long, 6 required
#4-40 NC × ½ long, 8 required
#6-32 NC × ¾ long, 10 required
#6-32 NC ×1″ long, 2 required

Hexagon Nut: #4-40 NC and #6-32 NC for the above screws.

Washers: Flat and lock for the above screws.

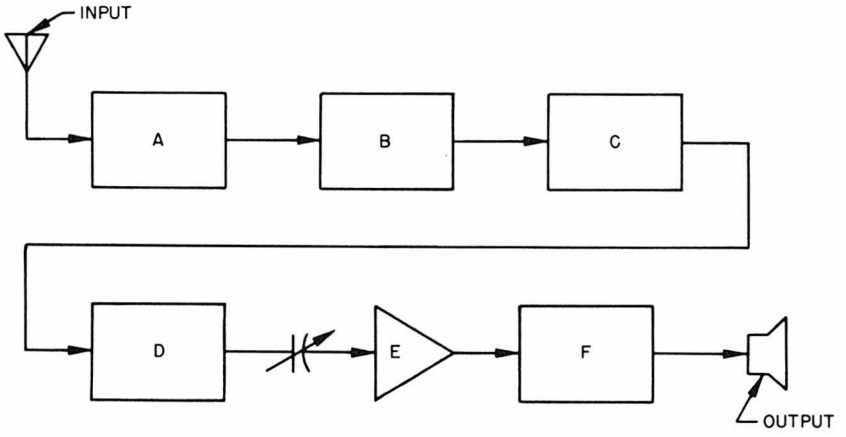
Finish the list below with the correct MS number for each piece of hardware.

HARDWARE	MILITARY STANDARD NUMBER	NO. REQ'D
SCREW #4-40 NC X 1/4	MS35221-13	6
WASHER-FLAT #6		
WASHER-LOCK, SPLIT #6		

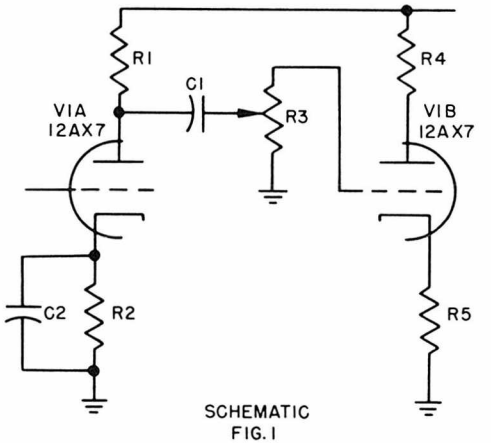
TITLE					DWG. NO.
COMPONENT OUTLINE-HARDWARE					COMP-2
NAME	DATE	COURSE	GRADE	SCALE NOTED	SHEET 2 OF 2 / PAGE 17

INTRODUCTION: THE BLOCK DIAGRAM

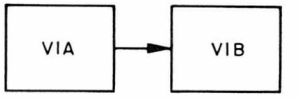
A block diagram outlines the path of a signal through a series of steps or operations. The steps are shown as "blocks" (of components) which omit the details but summarize a schematic drawing. (See example on right, Fig. 1.) The block diagram should start in the upper left and "read" **from left to right,** as shown in the example below.



In many cases a tube (such as a 12AX7) can be split in a schematic diagram as shown in Fig. 1 below. You will notice that to express this split in a block diagram one must indicate two blocks — namely, V1A and V1B, which is actually one tube.



SCHEMATIC
FIG. 1

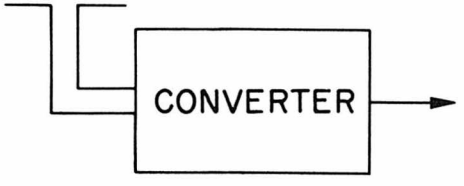


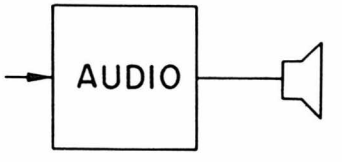
Block diagram of the schematic shown in fig. 1

Abbreviations can be used in block diagrams for condensing and simplifying the diagrams.
Abbreviations used in the following exercise are:

AMP (amplifier)
CONV (converter)
DEMOD (demodulator)
DISC (discriminator)
HORIZ (horizontal)
HV (high voltage)
OSC (oscillator)
VER (vertical)
CATH FOLL (cathode follower)

Exercise. Draw a block diagram of the **FM Tuner schematic diagram** on SCH-3 sheet 1 (page 27, upper left) by making every suggested modular breakdown (see note 3) a block. Label all the blocks as shown in the schematic. Do not show the power supply. Show direction of flow (arrowheads).





TITLE					DWG. NO.
BLOCK DIAGRAM– INTRODUCTION					BD-1
NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 1 / PAGE 18

Example. The block diagram shown below explains the pictorial diagram of Fig. 1, in which a microphone is hooked to the input of the amplifier and the output of the amplifier is hooked to the speaker. Notice direction of arrowheads from input to output.

BLOCK DIAGRAM

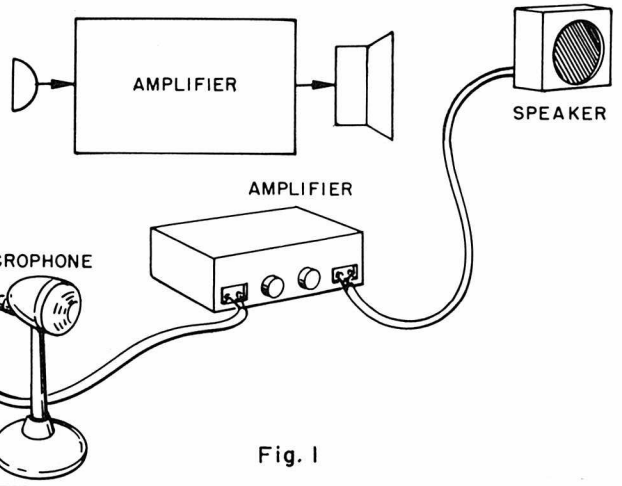


Fig. 1

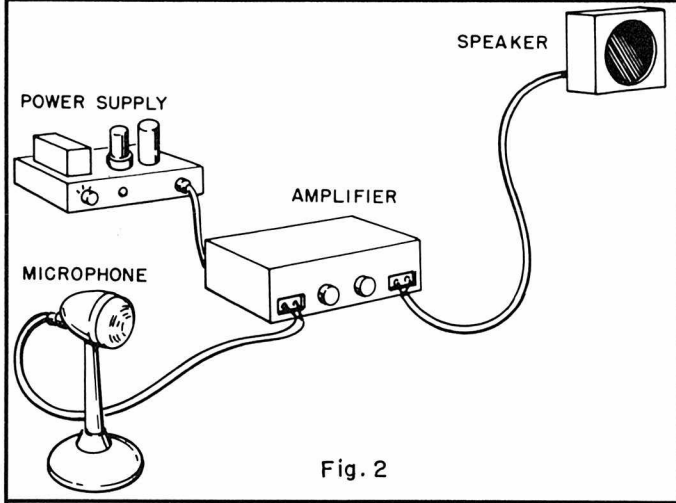
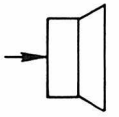
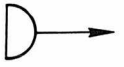


Fig. 2

Exercise 1. An identical setup of a simple intercom is shown in Fig. 2. The only difference is that a **power supply** was added to the **amplifier.** Draw a block diagram of the intercom of Fig. 2. Show the correct direction of arrowheads. (**Hint:** Power supplies are shown at bottom)



Exercise 2. Draw the same block diagram as you have shown in exercise 1, but add three more speakers hooked in parallel from the one output of the amplifier shown in Fig. 2. Show all arrowheads.



TITLE	BLOCK DIAGRAM – INTERCOM				DWG. NO. BD-2	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 1	PAGE 19

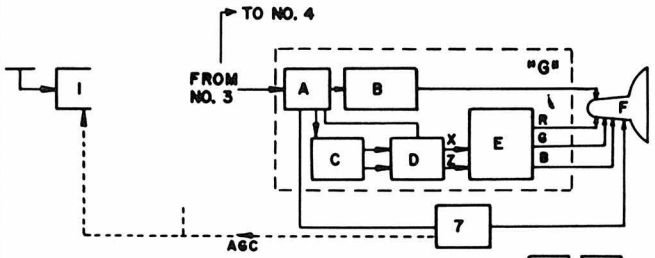


FIG. 1 COLOR TV RECEIVER

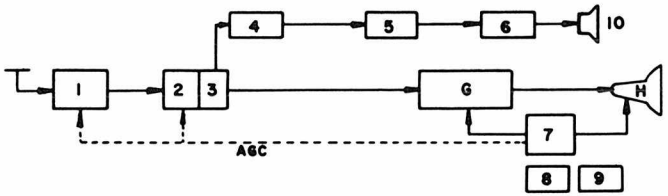


FIG. 2 BLACK AND WHITE TV RECEIVER

In this exercise you will be shown the basic comparison of a color and a black and white TV receiver. Fig. 1 shows an incomplete color TV receiver block diagram. Fig. 2 shows a complete black and white TV receiver block diagram.

Exercise. On sheet 1 (below) draw a complete black and white TV receiver block diagram as shown in Fig. 2. Instead of numbers and letters, fill in all the blocks with the correct nomenclature from the given list. Then on sheet 2 complete the color TV block diagram as shown in Fig. 1 by superimposing the black and white TV. The *numbered* blocks are identical in both diagrams. Notice that block 3 connects to A of *dashed block G.* Again, label all blocks with the correct nomenclature.

The following block identification will be used in both diagrams:

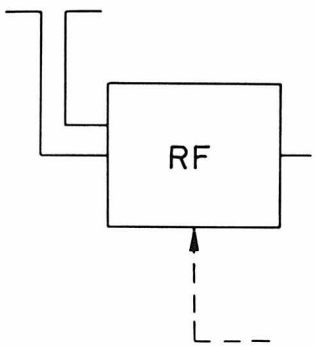
1 RF
2 PIX IF
3 DET
4 SOUND IF
5 SOUND DET
6 SOUND AMP
7 H&V, SYNC & DEFL
8 LOW VOLTAGE
9 HIGH VOLTAGE
10 LS

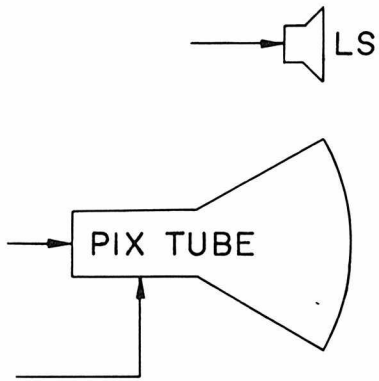
The following block identification will be used in the color TV only:

A 1st VIDEO
B LUMINANCE
C COLOR SYNC
D DEMODULATION
E COLOR DIFF AMP

The following block will be used by the black and white TV only:

G VIDEO

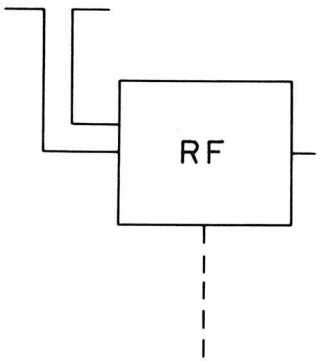


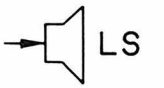


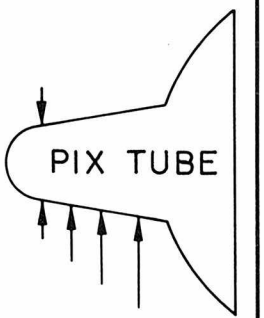
HIGH VOLTAGE

TITLE	BLOCK DIAGRAM—COLOR AND BLACK & WHITE TV RECEIVER COMPARISON				DWG. NO. BD-3	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 2	PAGE 20

Complete the started block diagram of the color TV receiver below, using sheet 1 (page 20) and list of blocks for reference. Label all blocks with the correct nomenclature.

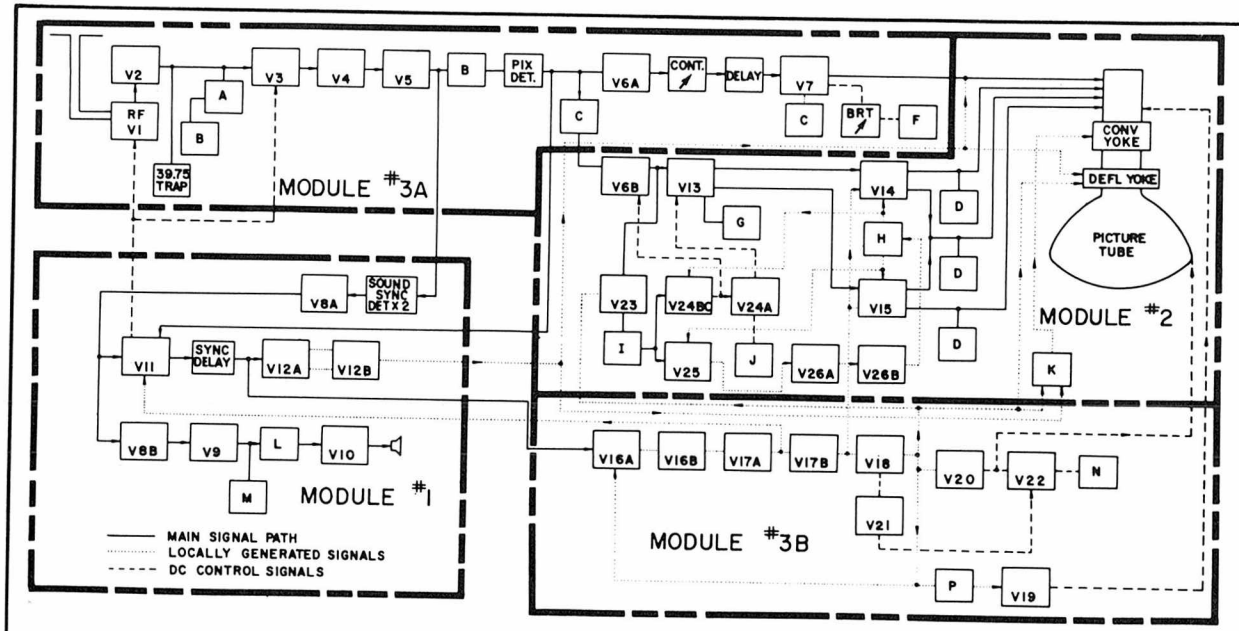






HIGH VOLTAGE

TITLE BLOCK DIAGRAM–COLOR AND BLACK & WHITE TV RECEIVER COMPARISON					DWG. NO. BD-3	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 2 OF 2	PAGE 21



A TYPICAL BLOCK DIAGRAM PROBLEM

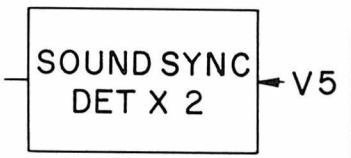
A project engineer wants a breakdown of the diagram shown at left to facilitate module design; each engineer is assigned to work on a separate diagram.

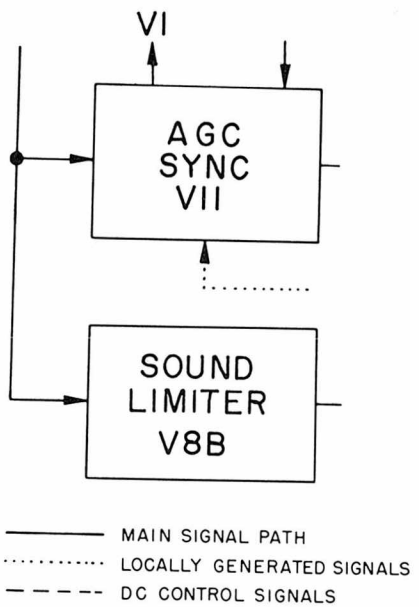
Prepare three separate block diagrams of the Zenith 27KC20 Color Television below and on the next two pages in the following order:

Sheet 1 Module #1 (below)

V11 AGC SYNC
V12A VERT OSC
V12B VERT OUT
V8B SOUND LIMITER
V9 SOUND DISC
V8A AMP
V10 SOUND OUTPUT
L VOL ↗
M TONE ↗

Then proceed to next page for continuation of the exercise.



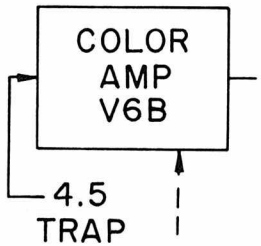


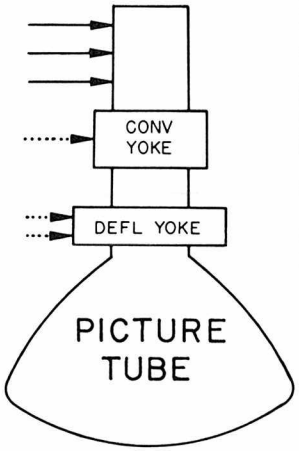
TITLE					DWG. NO.
BLOCK DIAGRAM—COLOR TELEVISION, MODULE NO. I					BD-4
NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 3 / PAGE 22

Complete the color television block diagram of Module #2 below. Use sheet 1 (page 22) for reference, use your own judgment for block spacing and lettering.

LIST OF BLOCKS

V6B COLOR AMP
V13 COLOR AMP
V14 B-Y DEMOD
V15 R-Y DEMOD
V23 BURST AMP
V24A COLOR KILLER
V24BC ACC ϕ DET
V25 AFC ϕ DET
V26A REACT TUBE
V26B COLOR OSC
D 3.58 TRAP
G COLOR LEVEL ↗
I HUE ↗
J KILLER ADJ ↗
K CONV ↗
H INJ. COIL



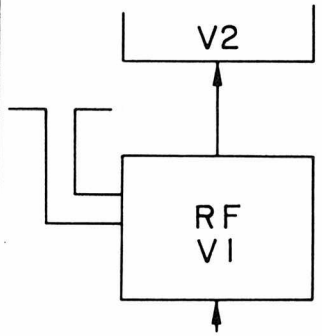


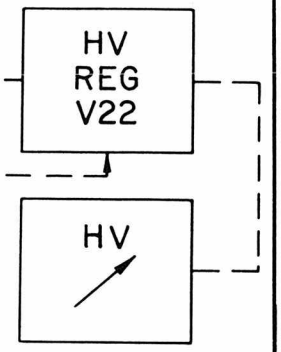
TITLE					DWG. NO.
BLOCK DIAGRAM – COLOR TELEVISION, MODULE NO. 2					BD-4
NAME	DATE	COURSE	GRADE	SCALE	SHEET 2 OF 3 / PAGE 23

Complete the color television block diagram of Modules #3A and #3B. Use sheet 1 (page 22) for reference, use your own judgment for block spacing and lettering. Orientation of blocks does not have to be exactly as shown in sheet 1 as long as the flow (direction) is correct.

LIST OF BLOCKS

V2 CONV	**V5** 3rd IF	**V16A** HORIZ ϕ DET	**V17B** HORIZ DISCH	**V20** HV RECT	**A** 47.25 TRAP	**F** BRT RANGE ↗
V3 1st IF	**V6A** CATH FOLL	**V16B** HORIZ CONTR	**V18** HORIZ OUT	**V21** DAMPER	**B** 41.25 TRAP	**N** HV ↗
V4 2nd IF	**V7** Y AMP	**V17A** HORIZ OSC	**V19** FOCUS RECT	**V22** HV REG	**C** 4.5 TRAP	**P** FOCUS ↗





TITLE		DWG. NO.
BLOCK DIAGRAM – COLOR TELEVISION, MODULE NO. 3A AND 3B		BD-4

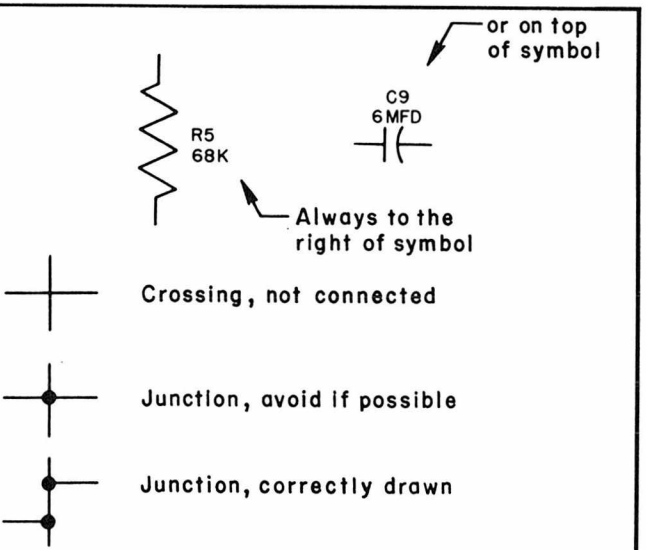
NAME	DATE	COURSE	GRADE	SCALE		PAGE
					SHEET 3 OF 3	24

INTRODUCTION: THE SCHEMATIC DIAGRAM

The best way to learn how to draw a schematic diagram is to follow a good example (like SCH-3 on page 27 of this lesson, the **FM Tuner**). However, a few other tips are worth mentioning.

1. Generally, lay out the spacing of transistors (or tubes) first and surrounding circuitry second.
2. Be sure to leave enough space for lettering between symbols.
3. Draw the complete layout lightly first and "heavy up" afterwards.

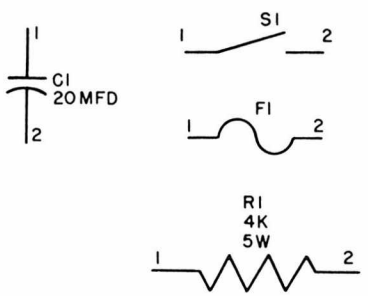
At right are properly drawn wire junctions, crossings, and typical symbol identifications and ratings. SCH-3 illustrates these and the lettering of notes. Notice that the last numbers used are included with the notes. Omitted numbers should also be listed as omitted (this often occurs after revisions have been made).

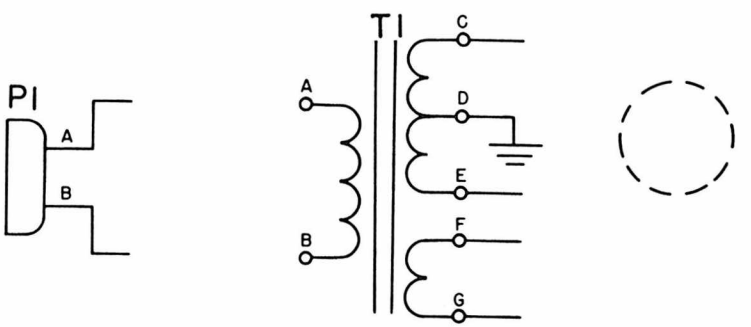


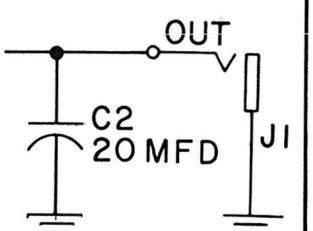
Exercise. Finish the schematic diagram below as follows: Look up the tube symbol of 5U4-G rectifier in Appendix B (page 81) . Draw the tube symbol of the 5U4-G inside the dotted circle. Label the tube V1.

Next, connect the following: V1 pin 4 to T1-E, V1 pin 6 to T1-C, V1 pin 2 to T1-F, V1 pin 8 to T1-G. Then replace the component symbols C1, S1, F1, R1 (listed below) in their proper position in the started schematic shown on the right and connect them as follows:

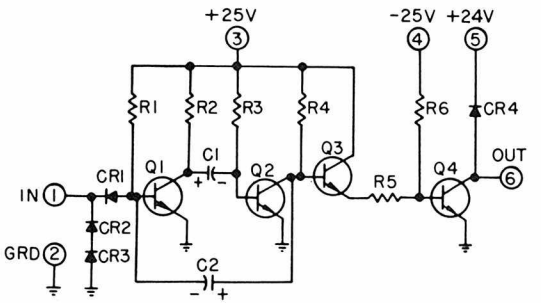
S1-1 to P1-A
S1-2 to T1-A
F1-1 to P1-B
F1-2 to T1-B
C1-1 to V1-2
C1-2 to GRD.
R1-1 to V1-2
R1-2 to OUT
T1-D to GRD.







TITLE SCHEMATIC DIAGRAM – INTRODUCTION					DWG. NO. SCH-1	
NAME	DATE	COURSE	GRADE	SCALE ~	SHEET 1 OF 1	PAGE 25



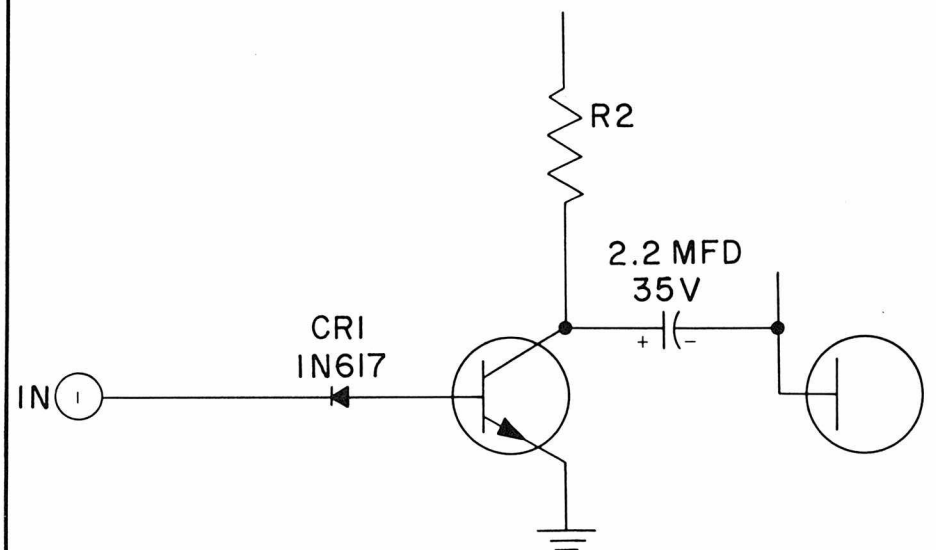
GATED MULTIVIBRATOR, SCHEMATIC DIAGRAM

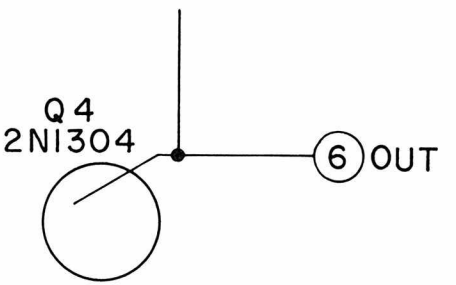
Exercise. From the schematic diagram shown at left, complete the schematic below according to the ASA manner (i.e., show identification and rating of each component). Use your own electronics template and complete the notes in the drawing below as follows:

Notes: Unless otherwise specified, 1. all resistance values are in ohms ¼ watt ±5%.

Indicate component ratings from the given table:

R1 and R3 = 560K	All capacitors = 2.2MFD, 35V
R2 and R4 = 22K	All diodes = 1N617
R5 = 33K	All transistors = 2N1304
R6 = 470K	

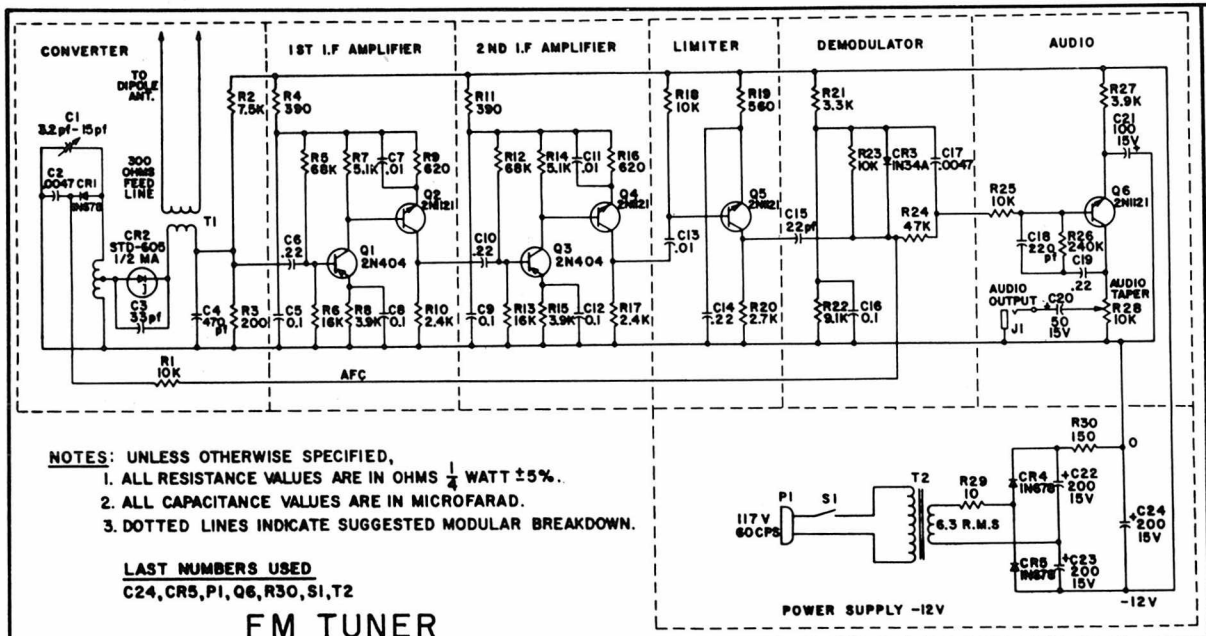




NOTES: UNLESS OTHERWISE

1.

TITLE					DWG. NO.
SCHEMATIC DIAGRAM— GATED MULTIVIBRATOR					SCH-2
NAME	DATE	COURSE	GRADE	SCALE ~	SHEET 1 OF 1 / PAGE 26



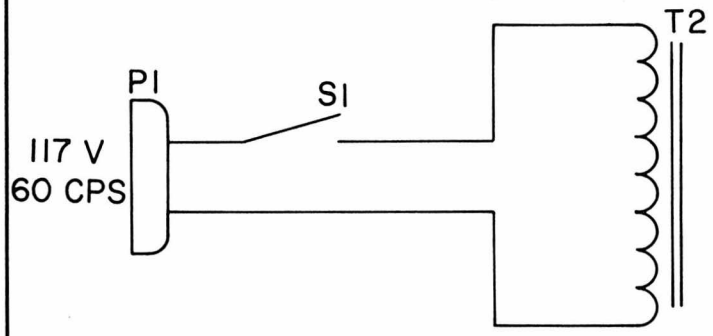
A TYPICAL SCHEMATIC DIAGRAM PROBLEM

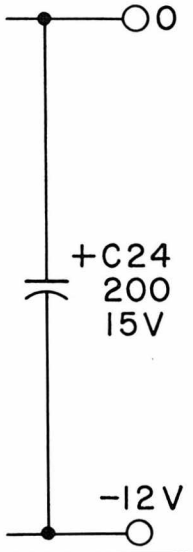
An engineer wants a breakdown of the circuit shown at left to facilitate module assembly; each technician is to work on a separate module. Prepare four separate schematic parts of the FM tuner below and on the next three pages in the following order:

Sheet 1 Complete the started power supply below.
Sheet 2 Complete the started converter and 1st IF amplifier.
Sheet 3 Complete the started 2nd IF amplifier and limiter.
Sheet 4 Complete the started demodulator and audio.

Use your electronics template. For symbols use Appendix A. Do not show the dotted lines.

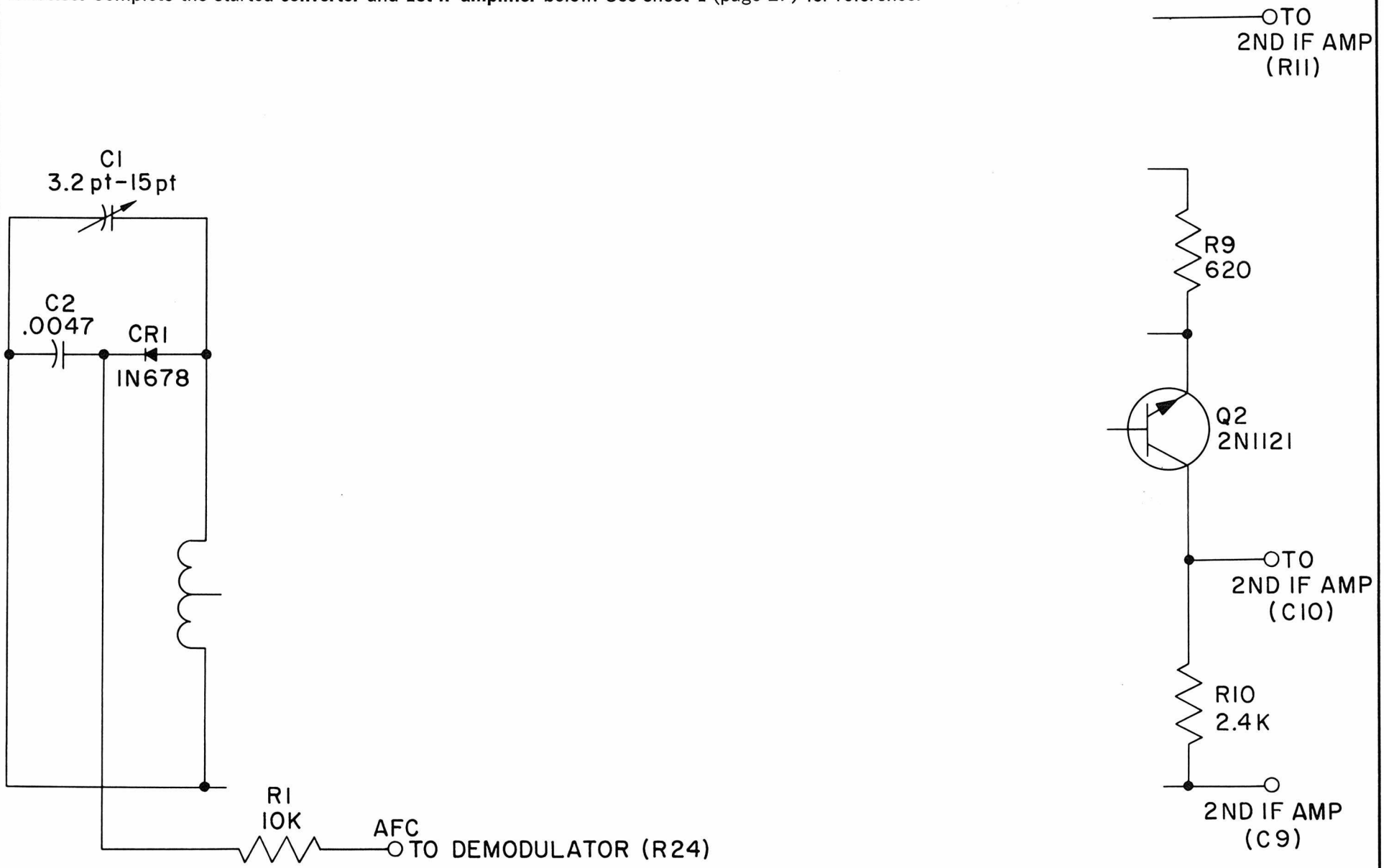
COMPLETE THE STARTED POWER SUPPLY OF THE FM TUNER BELOW.





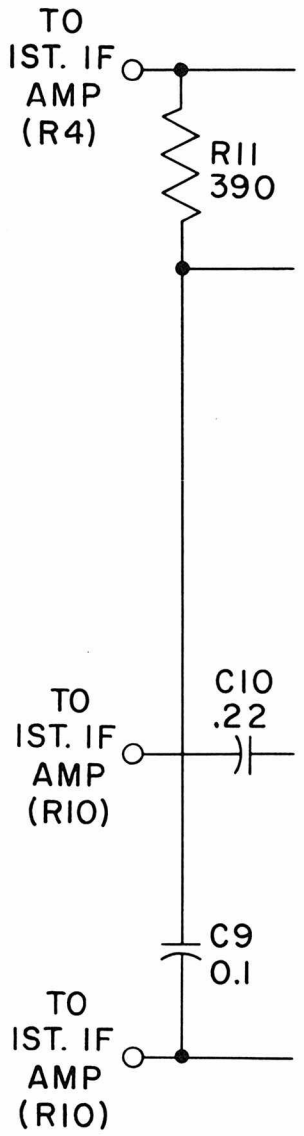
TITLE		DWG. NO.
SCHEMATIC DIAGRAM – FM TUNER, POWER SUPPLY		SCH-3
NAME	DATE / COURSE / GRADE / SCALE ~	SHEET 1 OF 4 / PAGE 27

Exercise. Complete the started **converter** and **1st IF amplifier** below. Use sheet 1 (page 27) for reference.



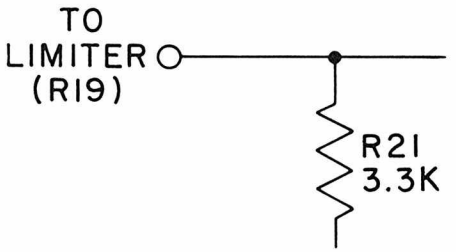
TITLE					DWG. NO.
SCHEMATIC DIAGRAM – FM TUNER, CONVERTER AND IST IF AMP.					SCH-3
NAME	DATE	COURSE	GRADE	SCALE ~	SHEET 2 OF 4 / PAGE 28

Exercise. Complete the started **2nd IF amplifier** and **limiter** below. Use sheet 1 (page 27) for reference.



TITLE					DWG. NO.
SCHEMATIC DIAGRAM – FM TUNER, 2ND IF AMP. AND LIMITER					SCH-3
NAME	DATE	COURSE	GRADE	SCALE ~	SHEET 3 OF 4 / PAGE 29

Exercise. Complete the started **demodulator** and **audio** below. Use sheet 1 (page 27) for reference.



TITLE					DWG. NO.	
SCHEMATIC DIAGRAM – FM TUNER, DEMODULATOR AND AUDIO					SCH-3	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 4 OF 4	PAGE 30

CABLE DRAWINGS

The typical cable drawing at right has all the necessary information to identify parts and to assemble and properly install the cable.

In general, code numbers are brief notations for full descriptions. For example,

CO-07 L G F (3/16-3/12-1/8) SJ 0500

- CO-07: (300V— / 600V) 7 wires
- L: light duty
- G: flexible / general purpose
- F: 3-#16 gage / 3-#12 gage / 1-# 8 gage wires
- SJ: .500 dia. shielded and jacketed
- 0500

MS3101E-24-16P = connector-plug (male) which requires no clamp, bushing, or insert numbers.
MS25036-3 or MS25036-8 = lug types
MW-C12(65)J = wire type (J = Jacketed)
- Medium Wall-Copper #12 gage (.0808D)65 strand

TB2/3-J16/1-6 = wire I.D. and destination
- Jacketed #16(0508D) brown-blue (1-6:see Color Code Appendix E)
- Terminal Board #2/terminal #3

V2/5-J8/6 = wire I.D. and destination
- Jacketed #8 (.1285) blue = plate
- tube #2/terminal #5 = plate (anode)

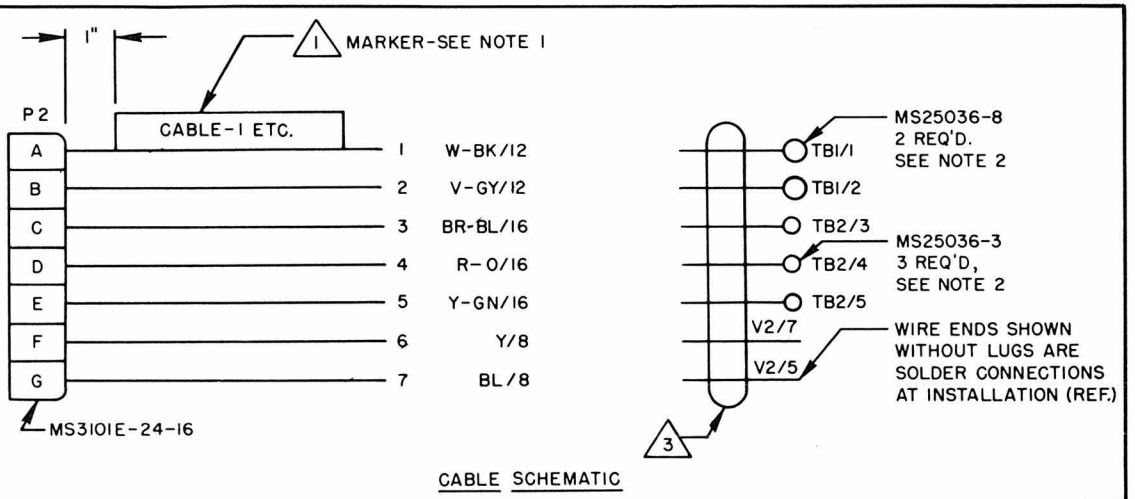
Exercise 1. From code #HW-C8 (133)J, HW = heavy wall; C = _____

8 = _____ J = _____

Exercise 2. From the schematic, 3 BR-BL/16 means wire #3 is colored _____ and is/_____ (Gage ?)

Exercise 3. Wire #TB2/4-J16/2-3 is colored and _____. Its destination is _____

(Hint: See wire table)



CABLE SCHEMATIC

WIRE TABLE

NO.	TYPE	LENGTH	FROM	TO	STRIP	REMARKS
1	MW-C12(65)J	6′-4½″	P2-A	TB1/1-J12/9-0	¼-½	ALL WIRES
2	MW-C12(65)J	6′-4½″	P2-B	TB1/2-J12/7-8	¼-½	PER SPEC
3	MW-C16(26)J	6′-5″	P2-C	TB2/3-J16/1-6	¼-⅜	MIL-W-
4	MW-C16(26)J	6′-5″	P2-D	TB2/4-J16/2-3	¼-⅜	16878
5	MW-C16(26)J	6′-5″	P2-E	TB2/5-J16/4-5	¼-⅜	TYPE B
6	HW-C8(133)J	6′-5½″	P2-F	V2/7-J8/4	¼-⅜	
7	HW-C8(133)J	6′-5½″	P2-G	V2/5-J8/6	¼-⅜	

3 CABLE TUBING: ALPHA #PVC-105-1/2″ BY 6 FT. LONG PER MIL-1-631C OR EQUIVALENT

2. LUGS FURNISHED UNATTACHED, TO BE CRIMPED AT INSTALLATION.

1 INK STAMP 1/8 CHARACTERS WITH BLACK INK AS FOLLOWS: CABLE-1 CO-07LGF (3/16-3/12-1/8) SJ 0500 ON CABLE TUBING AND COAT WITH CLEAR PLASTIC SPRAY 1″ FROM PLUG AS SHOWN.

NOTES:

TITLE	DWG. NO.
CABLE DRAWING—CABLE SCHEMATIC AND WIRE TABLE	CD-1

NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 3	PAGE 31

The same cable as was used on sheet 1 is shown here **orthographically** and **schematically.** This is an **assembly drawing** which requires a parts list to obtain parts and a schematic (or wire table) to properly assemble and install the cable. The section view suggests how the tubing size is selected. Notice here the use of the **arrow** rather than **block** symbol for **schematic multiplug.** (These are interchangeable).

Exercise 1. From sheet 1 complete schematic at right. Complete notes 1 and 2. Have note 3 explain which wires are to be stripped and by how much. Note 4 should mention the wire specifications.

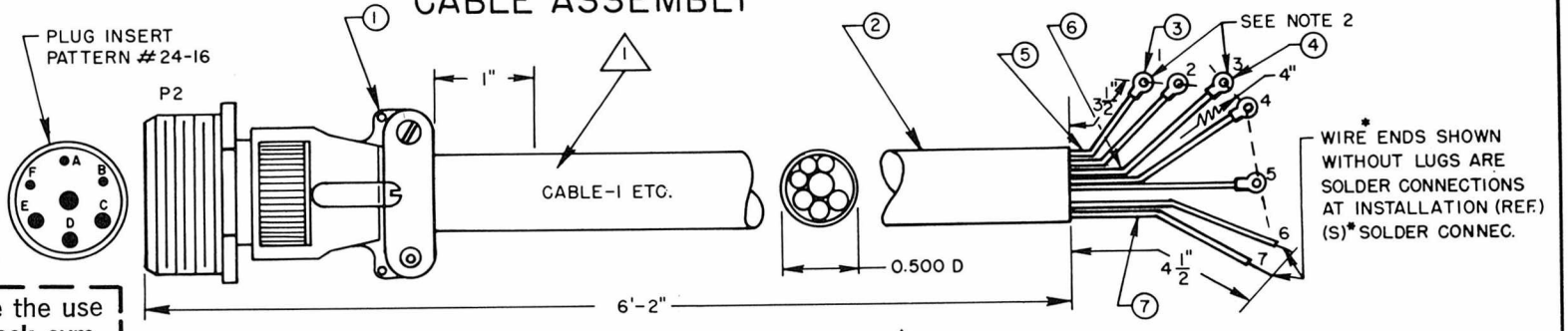
Exercise 2. From code number V2/7-J8/4

V2 =
7 =
J =
8 =
4 = YELLOW; CATHODE

Exercise 3. From code number CO-22HOE(10/8-12/10)SJ1500

E = extra flexible
O = oil resistant
H =
22 =
12/10 =
1500 =

CABLE ASSEMBLY



P2
A ← W-BK/12 ○ 1 (3) TB1/1-J12/9-0
B ← V-GY/12 ○ 2 (3)
C ← BR-BL/16 ○ 3 (4)
D ← R-O/16 ○ 4 (4)
E ← Y-GN/16 ○ 5 (4)
F ← Y/8 6 (S)* V2/7-J8/4
G ← BL/8 7 (S)

PLUG LETTER — WIRE NO. — COLORS/WIRE GAGE — TERMINAL (ITEM #) — DESTINATION-GAGE/COL. #

3 4

ITEM	NO. REQD	PART	DESCRIPTION
7	2	WIRE	HW-C8 (133) Jx6'-4 1/2"
6	3	WIRE	MW-C16 (26) Jx 6'-5"
5	2	WIRE	MW-C12 (65) Jx 6'-5 1/2"
4	3	LUG	MS25036-3
3	2	LUG	MS25036-8
2	1	TUBING	PVC-105-1/2"x6 FT. PER MIL-I-631C (ALPHA) OR EQ.
1	1	PLUG	MS3101E-24-16P

PARTS LIST

CABLE SCHEMATIC

NOTES:

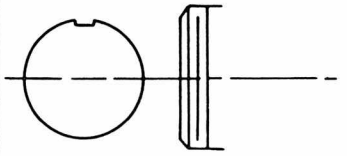
1

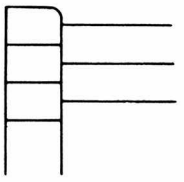
2.

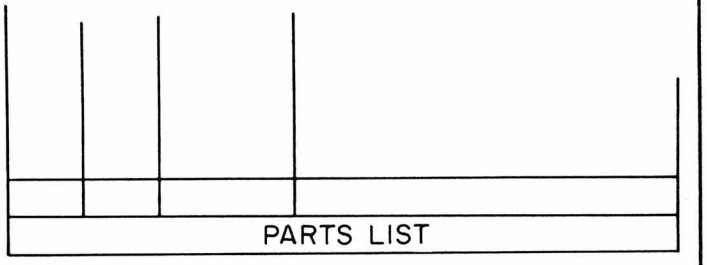
TITLE					DWG. NO.	
CABLE DRAWING – CABLE ASSEMBLY					CD-1	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 2 OF 3	PAGE 32

Make a **cable drawing** similar to that on sheet 2 with same plug "shell" (MS3101E) and insert #24-27P, which carries seven #16 wires (in the same pattern as #24-16P). Terminate all wires with the MS25036-3 lug 4″ beyond tubing. Tubing and plug length to be 8′-9″. All wires #1 through #7 to go from P2 to TB3, terminals #1 through #7 (wire #1 to terminal #1, wire #2 to terminal #2, etc.).

Have all wires **jacketed with color numbers** to match wire and terminal numbers. Complete "block" multiplug schematic and parts list. Use basically the same style format and notes as on sheet 2 (but call out revised **length of wires** and **tubing** plus revised **wire colors** and **size).**







2.

⚠1

NOTES:

TITLE CABLE DRAWING					DWG. NO. CD-1	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 3 OF 3	PAGE 33

MILITARY STANDARDS (MS)

Military Standards become known to draftsmen by many code numbers. Examples are:

MIL-STD-15 (electrical and electronics symbols)

MIL-A-8625 (anodize)

QPL-641-16 (jacks, telephone)

JAN-S-28 (sockets, electronic tube)

QQ-A-327 (aluminum sheet and plate)

MS35221-45 (screw, pan head)

In addition, there are hundreds whose code letters start with AN-, ANA-, EI-, AND-, and many others. These various Military Standards permit the electromechanical draftsman to use a **short code number** to represent a lengthy description or detailed drawing.

In industry the electronics draftsman spends a great deal of his time looking up electronic components, hardware and specs. Basically, the MS (Military Standard) number describes one of the following:

A booklet of general information

An engineering material

A fabricating process

An electronic component

A piece of hardware

Handling procedure (assembly, installation, or operation of equipment)

See examples of typical pages of Military Standards in Appendix C, pages 86-89.

Exercises. In order to answer the exercises below, refer to Appendix C, pages 86-89 (Military Standards).

1. What is MS35221-14?
   #4-40NC x 5/16 LONG, PAN HEAD SCREW

   _____

2. What is MS35649-84?

   _____

   _____

3. What is the outside diameter of MS35337-3?

   _____

   _____

4. What is the MS number of the following:

   #2, WASHER, FLAT GEN. PURPOSE CRES

   _____

   _____

   #2, WASHER, FLAT GEN. PURPOSE BRASS

   _____

   _____

   #6, LOCK WASHER, SPLIT, LIGHT SERIES, PLAIN _____

   _____

   _____

5. What information is given in the first four columns of MS15795?

   _____

   _____

   What are the rest of the columns used for?

   _____

   _____

   _____

6. What are the MS numbers of all the hardware shown in Fig. 1?

(HARDWARE MATERIAL — CRES)

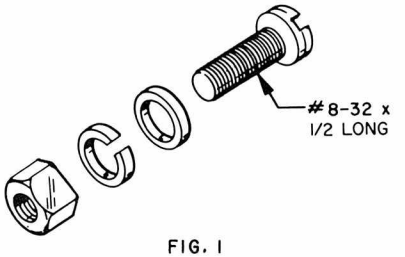


FIG. 1

SCREW _____

NUT _____

WASHER, FLAT _____

WASHER, LOCK _____

TITLE				DWG. NO.	
MILITARY STANDARDS — INTRODUCTION				MS-1	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 2 / PAGE
				NONE	34

A typical callout of a fastening using MS numbers might read as follows;

Example

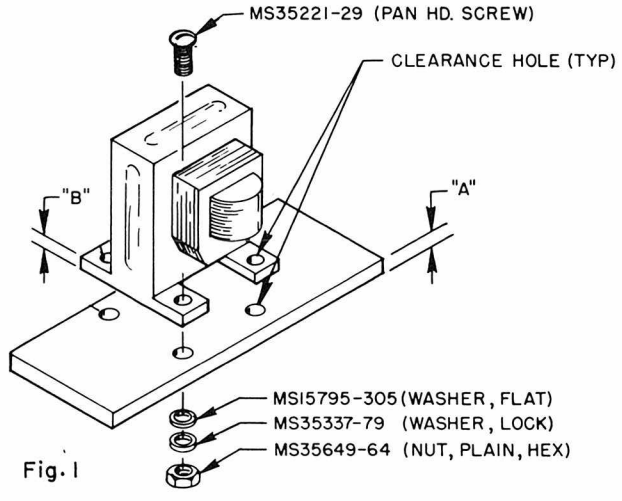


Fig. 1

Exercise 1. The following problems are related to Fig. 1 above.
If A is 1/16 thick, B = 1/16 thick, and a #6-32 pan head screw is used, what should the **length** of the screw be? Give the MS numbers.

SCREW _____
WASHER, FLAT _____
WASHER, LOCK _____
NUT, PLAIN, HEX _____

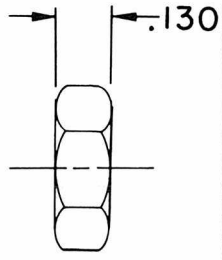
Exercise 2. Refer to the above problem and solve in the same manner if A = 1/8, B = 3/16, and a #8-32 screw is used?

SCREW _____
WASHER, FLAT _____
WASHER, LOCK _____
NUT, PLAIN, HEX _____

Exercise. Draw the following **hardware:** MS35221-47 and MS35649-84, 2 × size. See Appendix C. Show only the important dimensions.

MS35221-47 (side view)

MS35649-84 (2 views)



Exercise. Draw **switch** MS35058-21 full scale. See Appendix B (page 84). Show only the important dimensions.

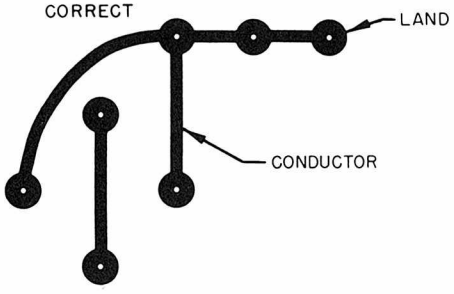
Front view

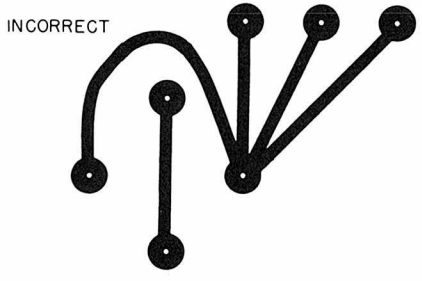
Side view

TITLE MILITARY STANDARDS					DWG. NO. MS-1	
NAME	DATE	COURSE	GRADE	SCALE NOTED	SHEET 2 OF 2	PAGE 35

PRINTED CIRCUIT PATTERN

The length of the conductors between various lands shall be held to a minimum.





Exercise 1: Connect the lands given in Figs. 1, 2, and 3 with a 1/16" wide black pressure-sensitive tape. Leave 1/16 minimum spacing from edge of board and component holes. If no tape is available, use pencil and draw the conductors 1/16 wide.

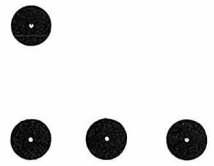


Fig. 1

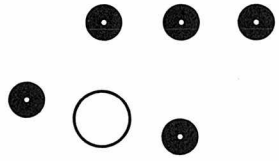


Fig. 2

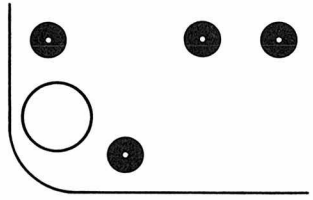


Fig. 3

Exercise 2. With a 1/16" wide tape connect the following in Fig. 4.

All lands marked A join together.
All lands marked B join together.
Connect nearest A hole to remaining connector tab (as shown with B hole to tab).

Make all connections on one side of board only, as shown, and keep the length of the conductors to a minimum.

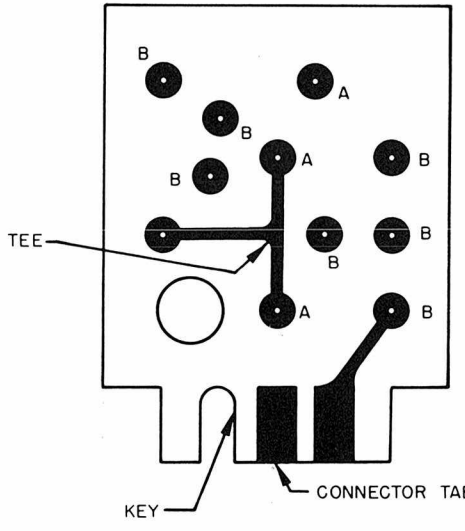


Fig. 4

Exercise 3. With a 1/16" wide tape connect the following in Fig. 5:

All 1 lands together to **Grd** (ground).
All 2 lands together to **Out.**
All 6 lands together.

Connect transistor as follows:

Base B to No. 4 tab.
Collector C to No. 5 tab.
Emitter E to land 3.

Avoid sharp corners.

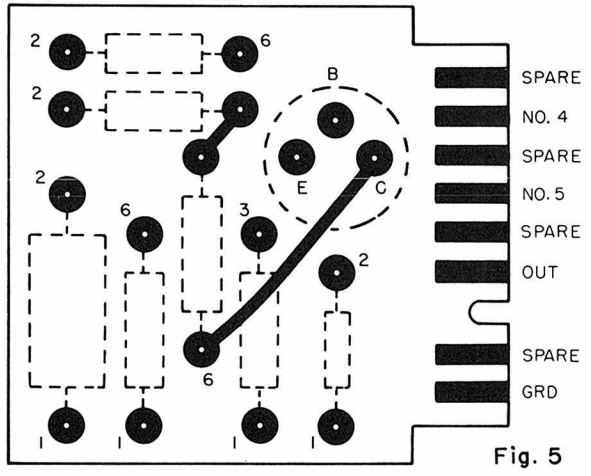
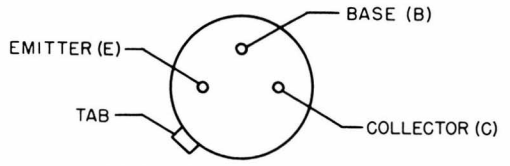


Fig. 5

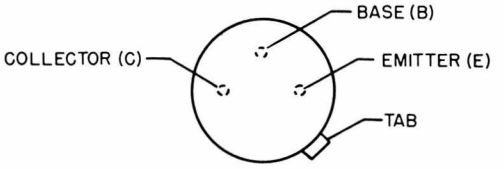
TITLE	PRINTED CIRCUIT BOARD–PRINTED CIRCUIT PATTERN				DWG. NO. PCB-1	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 1 OF 2	PAGE 36

TRANSISTOR AND DIODES IN PRINTED CIRCUIT BOARD (PCB)

Special attention should be given to laying out transistors and diodes in printed circuit boards. **Transistor leads** look different when viewed from the bottom (view *a*) than when viewed from the top (view *b*), as shown in Fig. 1.

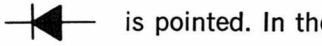
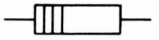


(*a*) Leads are seen solid.



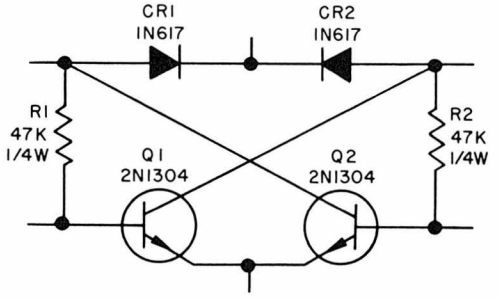
(*b*) Leads are seen dotted.

FIG. 1

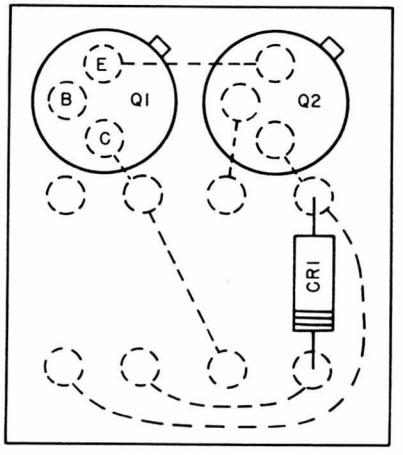
The secret lies in the **tab** of the transistor. The emitter (E) is closest to the tab of the transistor. The **diode** is easier to lay out. Always observe in the schematic to which side the cathode  is pointed. In the layout the diode should be installed in its proper orientation  or  .
It is important that the polarity of the diode be shown.

Exercise: From the schematic shown below make a layout of the components as seen from the top of the board (the circuit will be dotted) and as seen from the circuit side (the components will be seen dotted). Show all missing components and lines. Show **transistor tabs** in bottom view. Lay out one component lead per land. Component outline will be found in Appendix B.

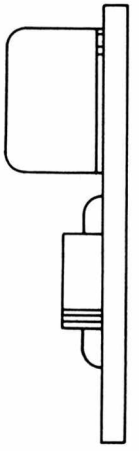
SCHEMATIC DIAGRAM



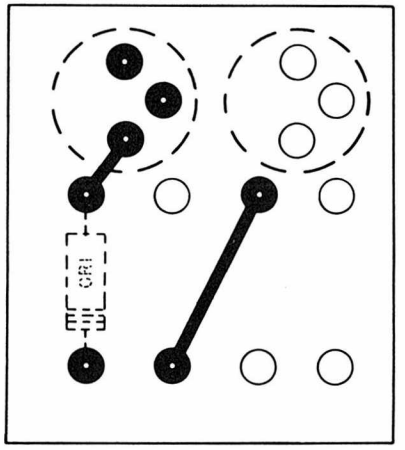
TOP VIEW
(component side)



SIDE VIEW



BOTTOM VIEW
(circuit side)



TITLE					DWG. NO.
PRINTED CIRCUIT BOARD—TRANSISTORS AND DIODES					PCB-1
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 2 OF 2 / PAGE 37

A TYPICAL, SINGLE-SIDED PCB

STEP-BY-STEP FABRICATION

Given: Schematic at right with component outlines, Appendix B.

Problem: Fabricate a printed circuit board. Mount all components on a single-sided board 1.0 x 1.0 x .062 thick, and make provision for #2-56 thread, pan head screws.

Solution: The next five steps or drawings in PCB fabrication are:

1. **Schematic** drawing
2. **Layout** drawing
3. **Master** (artwork) drawing
4. **Drill** and **contour** drawing
5. **Assembly** and **list of material** drawing

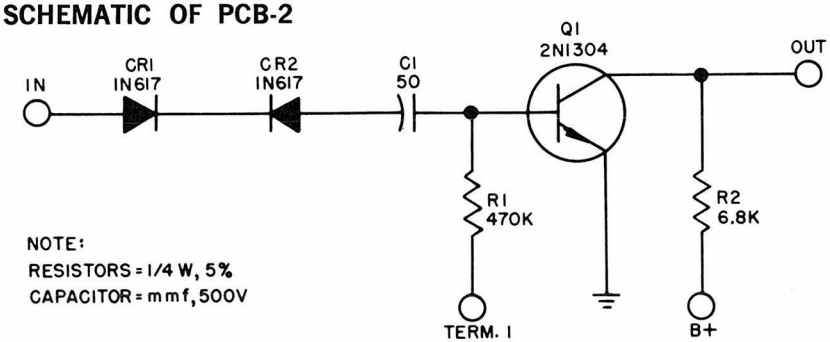
Since this is a Sample Exercise, all five steps have in large part been set up for the student to equip him for exercises to come.

HOW TO PREPARE THE LAYOUT

Lay out your board and components double size for photographing. Remember that the transistor is viewed from top (see previous exercise). *In dotted line or red pencil* show the conductors between lands. Show the screw head, three places. Mark components and polarity of diodes as shown. *Always make a neat, accurate layout.*

The layout should show screws (as shown in PCB-2) or any other fastener which will occupy space on the P.C. Board and displace circuitry or component area. Although the screws have to be shown in the layout, they are not considered part of the assembly and should not appear in the List Of Materials.

SCHEMATIC OF PCB-2

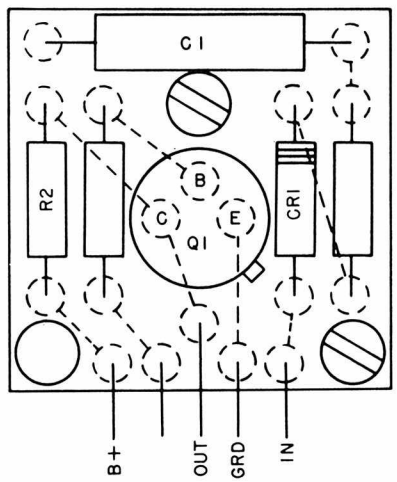


Step 1: SCHEMATIC (PCB-2)
Always draw the schematic first. Since this is a Sample Exercise, the schematic is shown completed.

Step 2: LAYOUT EXERCISE (PCB-2)
Complete the Layout.

1. How many electrical components are there?_____

LAYOUT OF PCB-2



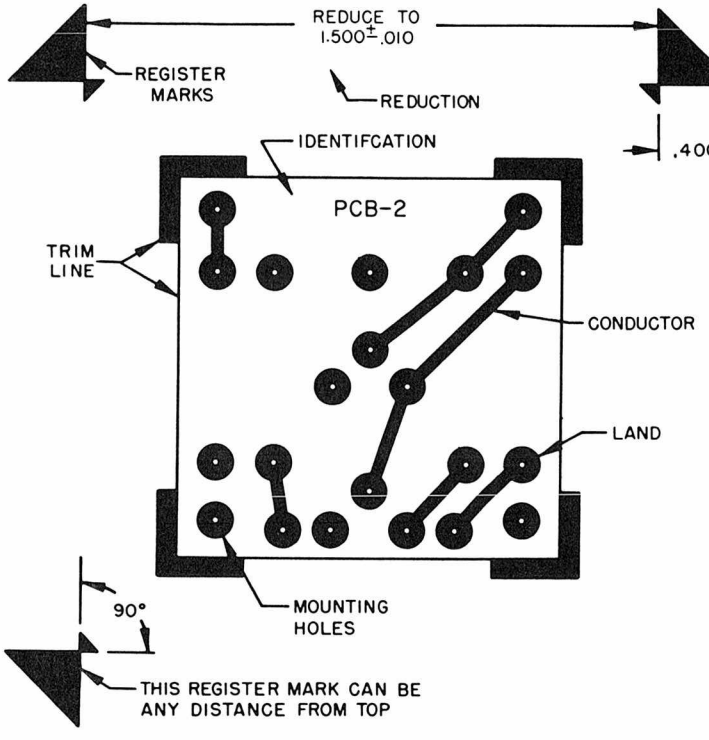
2. Two components are not identified. Show them in the layout. (See schematic diagram.)
3. Show polarity of all diodes.
4. One screw head is not shown finished. Complete it.
5. Identify all leads coming out of the board.
6. Check your layout against the schematic and fill in the missing dotted line.

TITLE					DWG. NO.
PRINTED CIRCUIT BOARD—SCHEMATIC AND LAYOUT (SINGLE SIDED)					PCB-2
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 1 OF 3 / PAGE 38

Step 3: PCB MASTER (Artwork)

Generally, the layout made in Step 2 is turned over and a sheet of mylar is placed on the reverse side. The layout is usually made on semitransparent vellum whose PCB pattern is visible from the back side through the mylar. The PCB pattern is now duplicated on the mylar with black tape conductors and/or decal lands. If you had made a master of PCB-2, it would be similar to the sample shown below.

The master (artwork) should show the following:



1. Reduction
2. Register marks
3. Conductors
4. Lands
5. Mounting holes
6. Trim line
7. Printed Circuit Board identification

Exercise. The sample is not completed. Show the two missing conductors. Check against your layout, Step 2.

Remember: your layout is inverted with respect to your master.

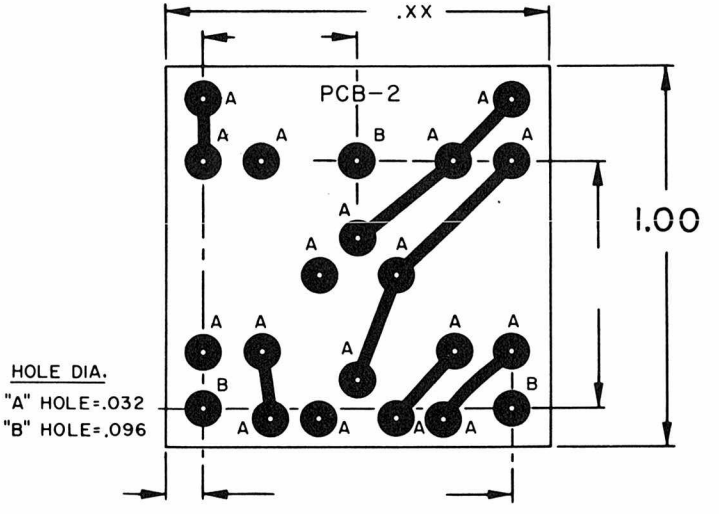
Step 4: PRINTED CIRCUIT BOARD DRILLED (PCB-2)

This step is needed so that the printed circuit board can be fabricated after the etching is done. Include the following data in all exercises to come:

1. Show all hole-diameter callouts.
2. Show board mounting hole center dimensions.
3. Show the shape and size of finished board dimensions.
4. **Material:** .062 thick Epoxy glass cloth laminate with .0027 CU one side (CU = copper)
5. **Finish:** Gold flash on etched lettering and conductors.

Exercise: See illustration below.

1. What should the .XX dimension be? _____
2. What are the A holes for? _____
   How many A holes are there? _____
3. What are the B holes for? _____
   How many B holes are there? _____
4. Complete the missing dimensions.
5. Show the two missing conductors as in step 3.



TITLE					DWG. NO.
PRINTED CIRCUIT BOARD – MASTER AND DRILLED (SINGLE SIDED)					PCB-2
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 2 OF 3 / PAGE 39

Step 5: PRINTED CIRCUIT BOARD ASSEMBLY (PCB-2)

The following items must be shown:

1. Assembly of all components as seen mounted on board. It will be the same as your layout, except that the dotted line and lands will not be seen since it is on the opposite side of the board.

2. All components and identification. *Always make it clear so that anyone could assemble the board from your assembly drawings.*

3. The assembly drawing should always be accompanied by a complete list of material, as shown below.

ITEM	NO. REQ.D	REFERENCE DESIGNATION	DESCRIPTION	MANUFACTURER & PART NO. OR MIL TYPE DESIGNATION
7				
6				
5				
4	2	CR1, CR2	DIODE	
3	1	C1	Capacitor	
2	1	PCB-2	PRINTED BOARD	1.00 x 1.00 x 0.62 Epoxy Glass
1	X	———————	SCHEMATIC	SHEET 1 of 3

LIST OF MATERIAL

Exercise

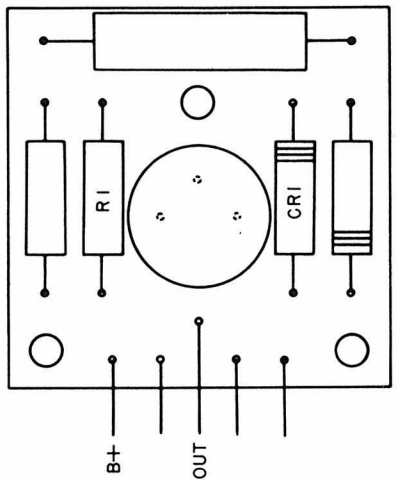
1. Complete the assembly drawing below. Show all component identifications.

2. Complete the list of material (see Appendix B and schematic diagram on page 38).
   Resistors are listed on page 77 (MIL STYLE RC07).

   Capacitors are listed on page 74 (MIL TYPE CM-15).

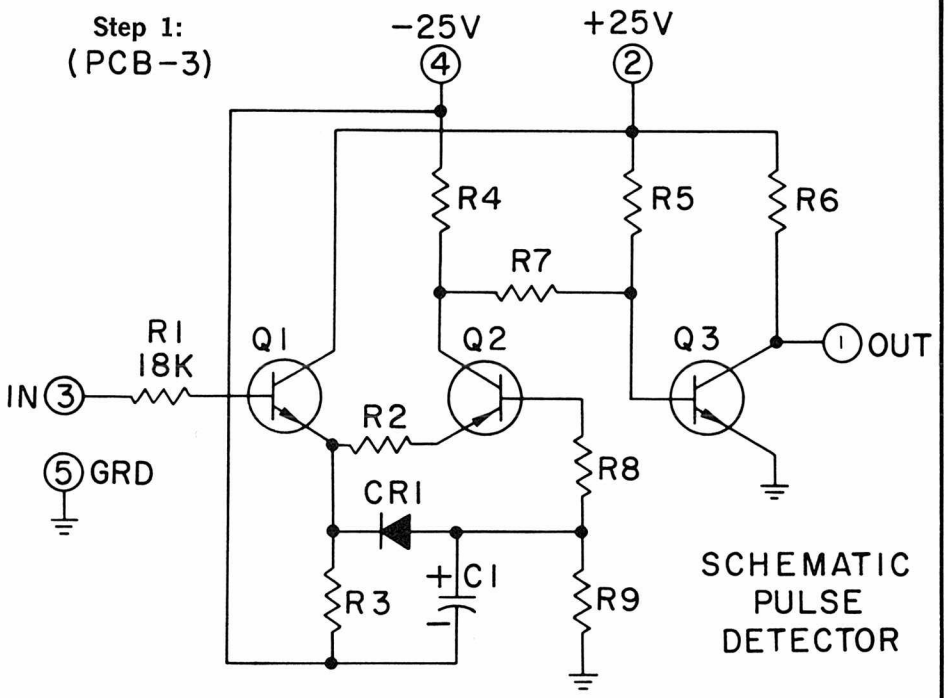
   Diodes are listed on page 76.

   Transistors are listed on page 80.



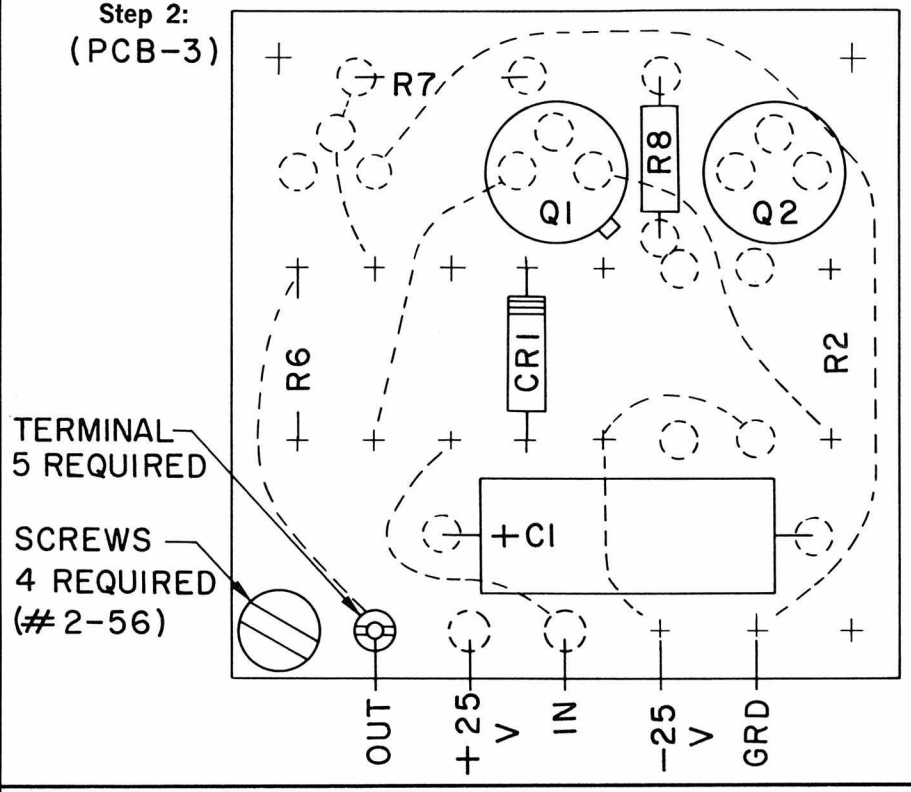
TITLE PRINTED CIRCUIT BOARD – ASS'Y AND LIST OF MATERIAL (SINGLE SIDED)					DWG. NO. PCB-2	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 3 OF 3	PAGE 40

Step 1:
(PCB-3)



NOTE: ALL RESISTANCE VALUES ARE IN OHMS
K=1000, M=1000000, 1/4W, 5 %

Step 2:
(PCB-3)



Step 1: SCHEMATIC (PULSE DETECTOR)

Complete the schematic according to the ASA manner. Include component values or type numbers with each component identification number.

R2 = 1K	R6 = 8.2K	Q1 = 2N338	C1 = 22mfd., 35V
R3 = 12K	R7 = 180K	Q2 = 2N1305	CR1 = 1N483A
R4 = 6.8K	R8 = 33K	Q3 = 2N1304	
R5 = 220K	R9 = 820K		

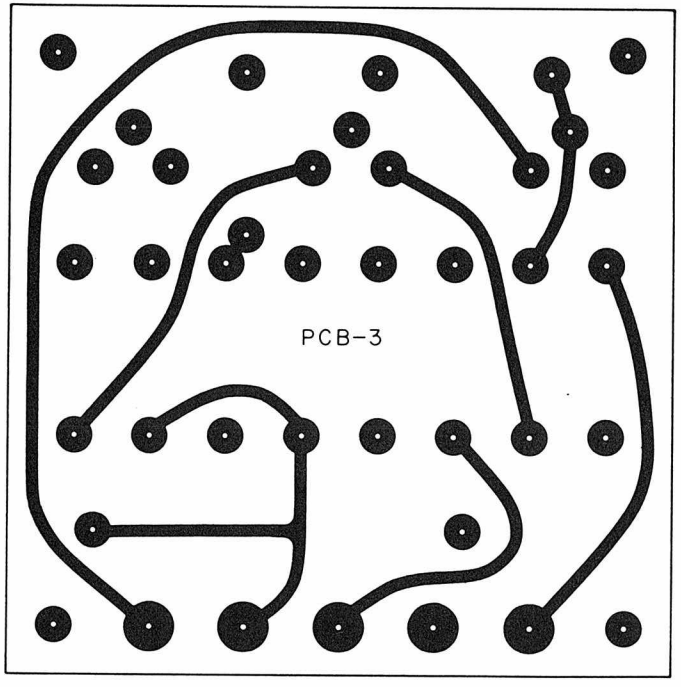
Step 2: LAYOUT (PULSE DETECTOR)

Complete the layout above, 2 × size. The component sizes are shown in Appendix B. Terminals are USECO No. 2000B. Screws #2-56 pan head. Board thickness .062 Epoxy glass cloth laminate. Check your layout against the schematic in step 1. Draw **components** in solid line and **conductors** in dotted line (they are on opposite sides of the board). Then proceed to step 3. (Page 42)

TITLE					DWG. NO.
PRINTED CIRCUIT BOARD–DETECTOR, SCHEMATIC AND LAYOUT					PCB-3
NAME	DATE	COURSE	GRADE	SCALE	PAGE
				2 X SIZE	SHEET 1 OF 3 — 41

Step 3: PRINTED CIRCUIT BOARD MASTER (ARTWORK)

Complete the master, following the same method used in sample exercise, PCB-2. Show reduction. (Reduce to 2.250 $\pm$.010, which will reduce the board to half size giving a 1.750 x 1.750 full-size board.) Show register marks, conductors, etc.



Step 4: PRINTED CIRCUIT BOARD DRILLED

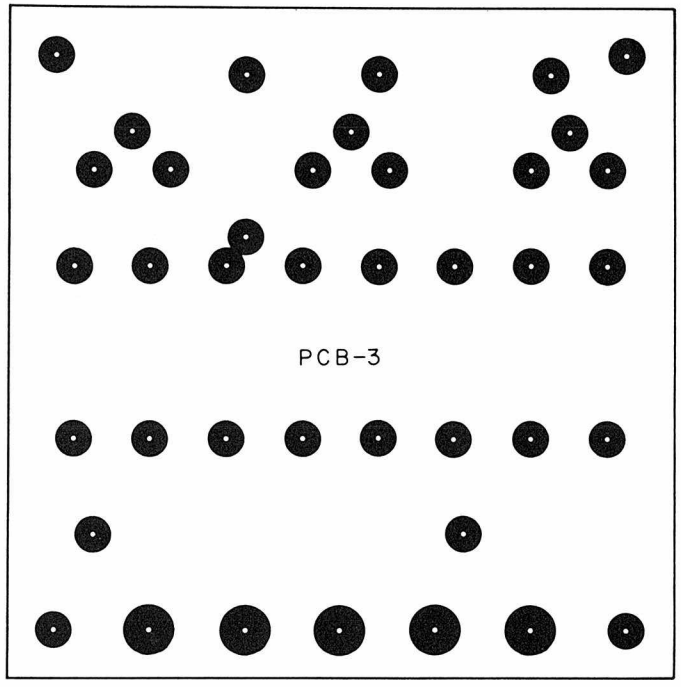
Follow the same method used in sample exercise PCB-2. Complete the drawing of the board below. For clarity do not show conductors again but show all dimensions necessary for fabrication of board.

Hole diameter

A (land hole) = .032 Dia.

C (terminal mounting holes) = .065 $^{+.003}_{-.001}$ Dia.

Calculate **clearance B holes,** four places for #2-56 pan head screws (Use Formula, Appendix D)

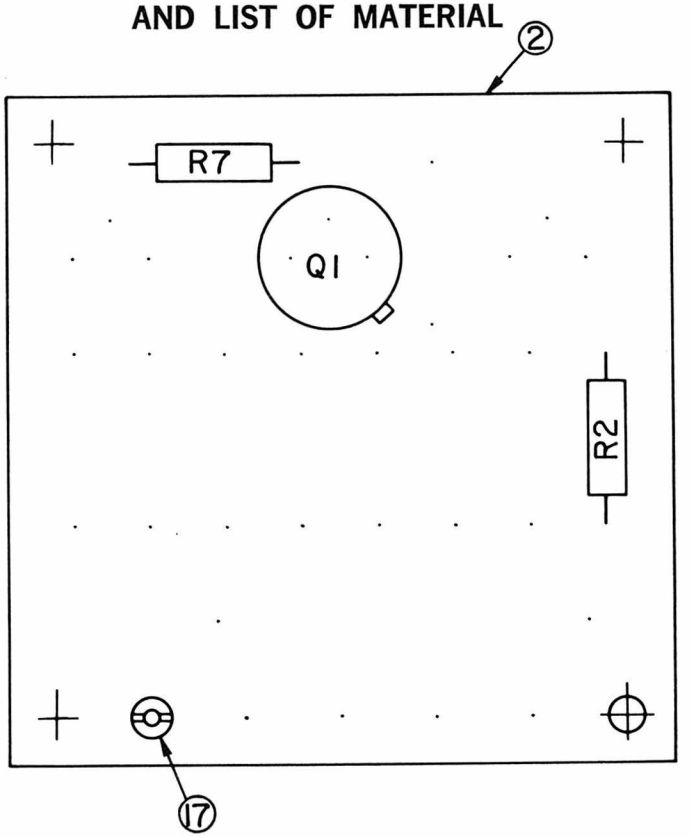


TITLE	PRINTED CIRCUIT BOARD—DETECTOR, MASTER AND DRILLED BOARD				DWG. NO. PCB-3	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 2 OF 3	PAGE 42

ITEM	NO. REQ'D	REFERENCE DESIGNATION	DESCRIPTION	MANUFACTURER AND PART NO. OR MIL TYPE DESIGNATION
17			TERMINAL	USECO NO. 2000B
16			RESISTOR	
15				
14				
13				
12				
11				
10				
9				
8		R1	RESISTOR	18K, 1/4W ±5% RC07GF183J
7		Q3		
6		Q2		
5		Q1		
4		CR1		
3		C1	CAPACITOR	
2	1	PCB-3	PRINTED BOARD	
1	X		SCHEMATIC	SHEET 1 OF 3 (PAGE 41)

LIST OF MATERIAL

PRINTED CIRCUIT BOARD ASSEMBLY AND LIST OF MATERIAL



Step 5: PRINTED CIRCUIT BOARD ASSEMBLY

Include the following:

1. A list of material as shown above. Use separate sheet if needed.
2. An assembly drawing of board and components as shown. (You do not see the conductors in the assembly drawing on a one-sided printed circuit board. It is not necessary to show item numbers for electrical components.)

Exercise

1. Complete the list of material. (See Appendix B for reference.)
2. Complete the layout. Show all components and wiring identification.
3. What are the five basic steps in PCB design? Complete this list.

TITLE	DWG. NO.
PRINTED CIRCUIT BOARD – DETECTOR, ASS'Y AND LIST OF MATERIAL	PCB-3

NAME	DATE	COURSE	GRADE	SCALE	SHEET 3 OF 3	PAGE 43

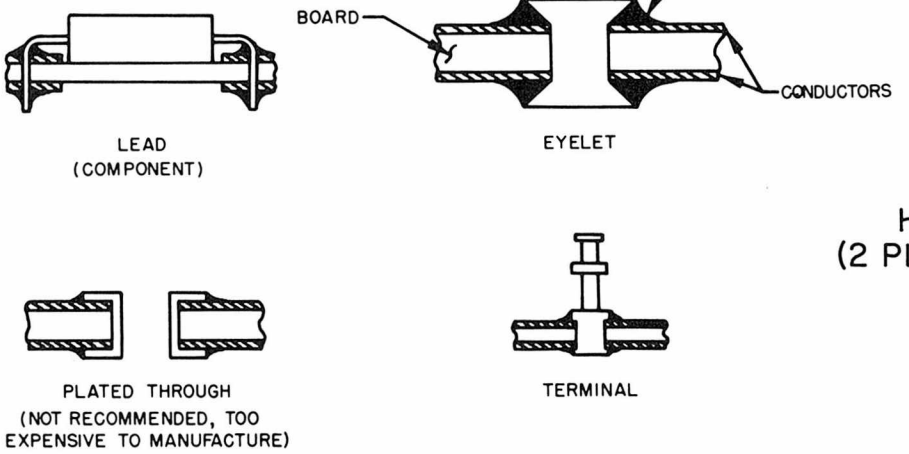
DOUBLE-SIDED PRINTED CIRCUIT BOARDS

Double-sided PCBs have the following features:

1. They are more expensive to manufacture than single-sided PCBs.
2. They are used where space is limited.
3. In double-sided boards the components are on *one or both* sides of the board.
4. Conductors are on *both sides* of the board.
5. An accurate layout is required in order to line up the front and back faces of the board; therefore, tool holes are required for machining.

CONNECTING THE FRONT AND BACK FACE OF THE BOARD

The four general methods for accomplishing through connection between two sides of a double-sided PCB are (1) leads, (2) eyelets, (3) plated-through holes, and (4) terminals.

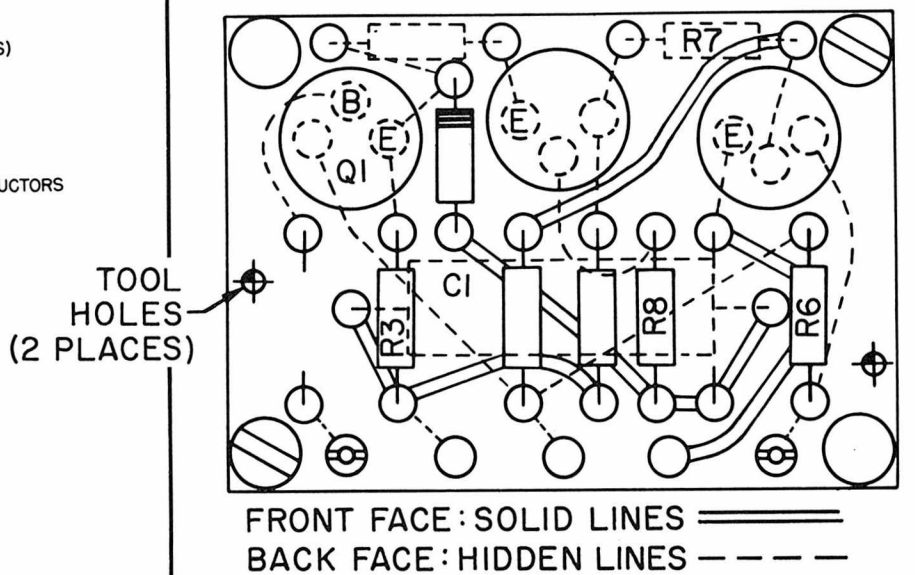


Exercise (Step 1 and Step 2 PCB-4)
From the same schematic diagram Pulse Detector and list of material in Exercise PCB-3, Fabricate a double-sided PCB.

Given:

1. **Schematic,** Exercise PCB-3, Step 1. (Page 41)
2. **List of material,** Exercise PCB-3, Step 5. (Page 43)
3. **PCB-4,** 1.750 x 1.250 x .062 thick. (Notice the board is now smaller in size than PCB-3.)

PROBLEM: Complete the started layout of PCB-4 below. Show transistor tabs in proper location. **Three components,** shown with hidden lines, are mounted on the back side of the board.



TITLE	PRINTED CIRCUIT BOARD – DOUBLE SIDED, BOARD LAYOUT			DWG. NO. PCB-4	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 1 OF 4	PAGE 44

Step 3: MASTER (ARTWORK) PCB-4

The method is the same as in the single-sided board, except that in the double-sided PCB **two masters** (two pieces of artwork) are needed for photographing.

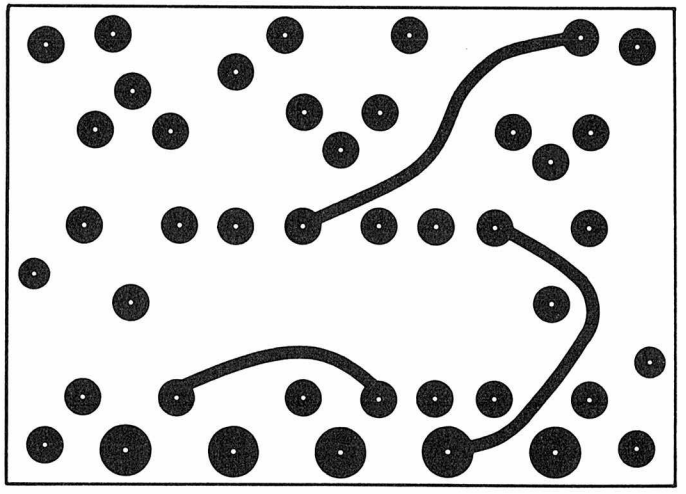
Exercise: PCB-4

Complete the two masters (both sides of PCB-4) below. Follow the same method used in preparing the master (artwork) of PCB-3 (step 3).

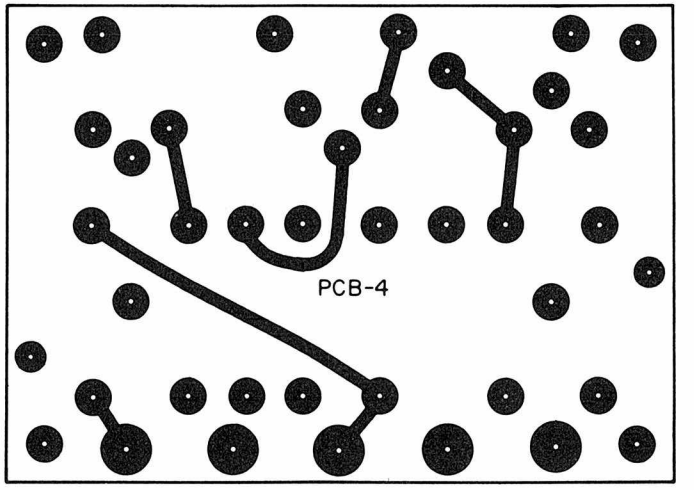
The **front-face master** is prepared from the layout with *solid lines.*

The **back-face master** is prepared from the layout with *hidden lines.*

Show the correct reduction of PCB-4 for both sides (**Hint:** board size is 1.750 x 1.250 x .062) Tool holes are already shown in both masters.



FRONT FACE



BACK FACE

TITLE PRINTED CIRCUIT BOARD—DOUBLE SIDED, BOARD MASTERS					DWG. NO. PCB-4	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 2 OF 4	PAGE 45

Step 4: PCB DRILLED (DOUBLE-SIDED PCB-4)

The method is the same as in a single-sided board. Choose the master with the identification PCB-4. Since the lands on both sides of the PCB are aligned, drilling may be done through either side.

Exercise: PCB-4

Complete the PCB-4 drilled drawing below in the same manner as was used in Exercise PCB-3 (step 4). Add the tool holes (.062 Dia.) and complete all the notes, hole chart, etc.

NOTES

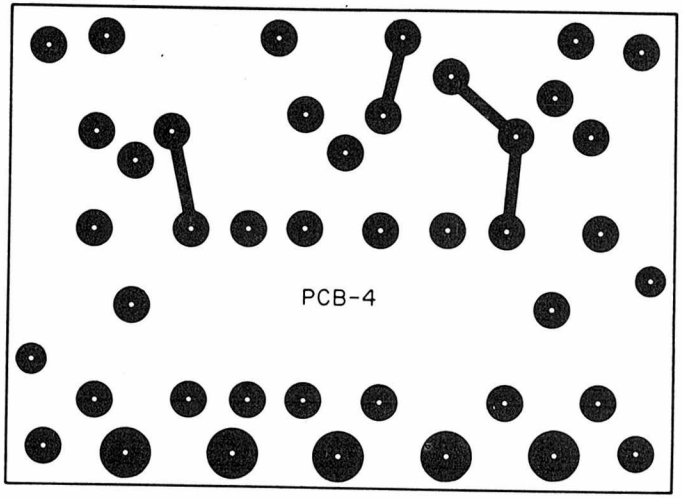
MATERIAL : .062 THICK EPOXY_ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

FINISH : GOLD_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _BOTH SIDES.



HOLE CHART			
DESCRIPTION	LETTER	DIA.	NO. REQ'D
LAND HOLES	A		
BOARD MTG. HOLE	B		
TERMINAL HOLE	C	$.065^{+.003}_{-.001}$	
TOOL HOLES	D		2

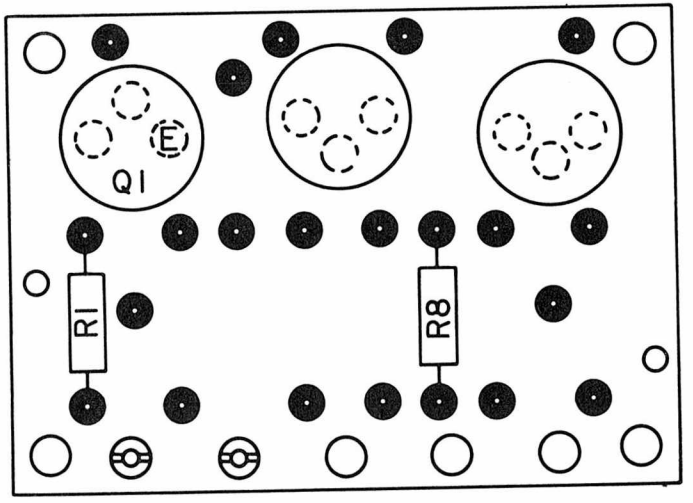
TITLE	PRINTED CIRCUIT BOARD – DOUBLE SIDED, BOARD DRILLED				DWG. NO. PCB-4	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 3 OF 4	PAGE 46

Step 5: ASSEMBLY (DOUBLE-SIDED PCB-4)

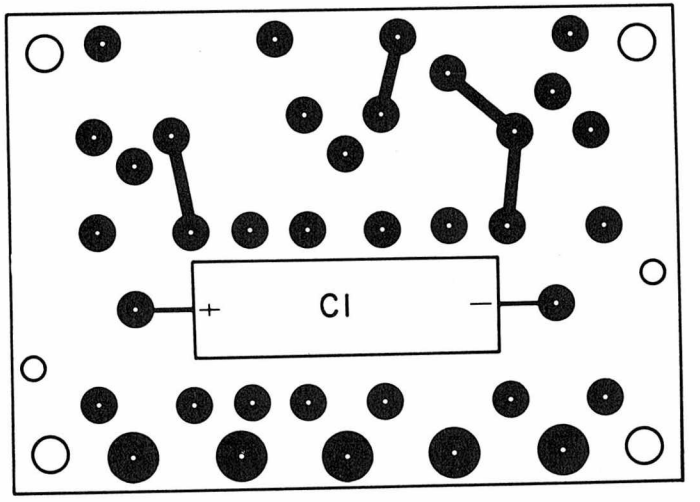
The assembly is prepared in the same manner as the single-sided board PCB-3 (step 5). The only difference is that in the double-sided PCB *two sides* are to be shown — the front and the back — with all the component identifications. Since this exercise has the same list of material as in PCB-3, it is not necessary to show it again.

Exercise: PCB-4

Complete the assembly drawing below by showing all the components. Some of the conductors have been omitted for clarity. Do not draw them in.



FRONT FACE



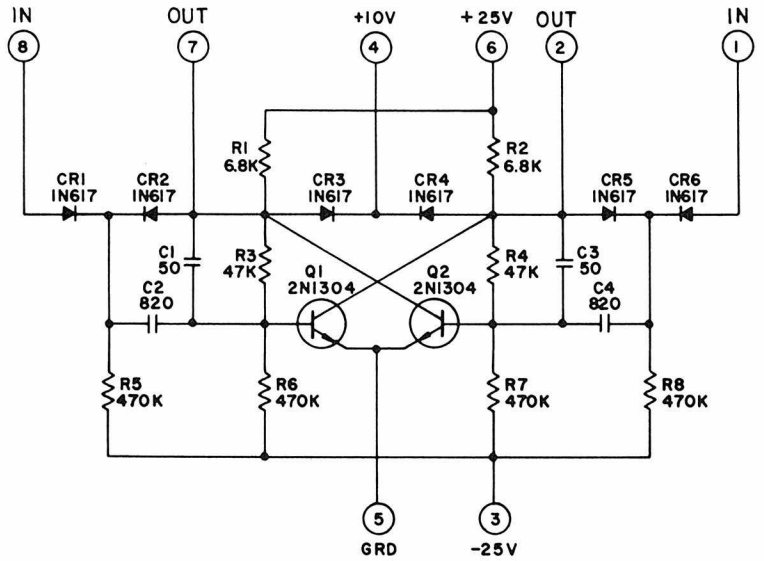
BACK FACE

TITLE PRINTED CIRCUIT BOARD – DOUBLE SIDED, BOARD ASSEMBLY					DWG. NO. PCB-4	
NAME	DATE	COURSE	GRADE	SCALE 2X SIZE	SHEET 4 OF 4	PAGE 47

Exercise: PCB-5 (PRINTED CIRCUIT BOARD)

From the schematic of the **Flip-Flop (PCB-5)** shown below, prepare all the drawings required (four more) to fabricate a **Single-Sided PCB-5** (see exercises PCB-3).

SCHEMATIC DIAGRAM-PCB-5
FLIP-FLOP

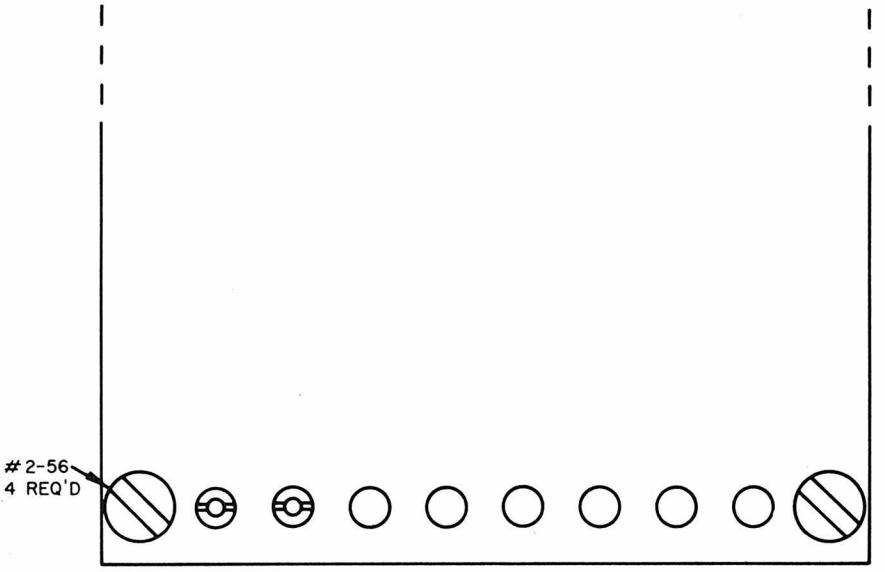


NOTES:

1. ALL RESISTANCE VALUES ARE IN OHMS, (K = 1000, M = 1000000) ¼W, 5%.
2. ALL CAPACITANCE VALUES ARE IN MICROMICROFARADS.

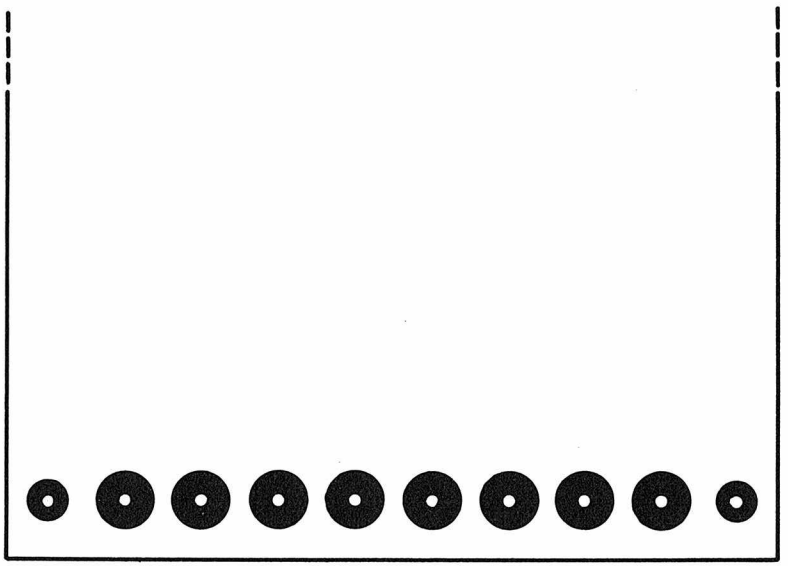
Exercise: PCB-5

Start with the Layout below (2 × size). Make the length of the board layout as compact as possible. Spacing between components, land, conductors, etc. should be $\frac{1}{32}$ minimum ($\frac{1}{16}$ in 2 × size layout). All required data may be found in Appendixes (outline and hardware) B and C. Identify this board as PCB-5.

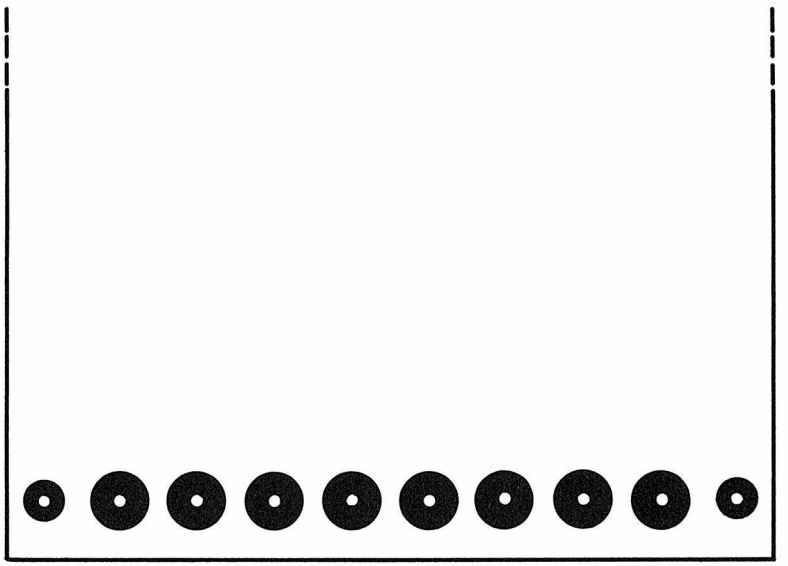


TITLE					DWG. NO.	
PRINTED CIRCUIT BOARD – FLIP-FLOP (SINGLE SIDED)					PCB-5	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 1 OF 3	PAGE 48

Exercise: PCB-5 (MASTER, ARTWORK)
Complete the master of PCB-5 below. Use either pencil or tapes, as instructed by your teacher.

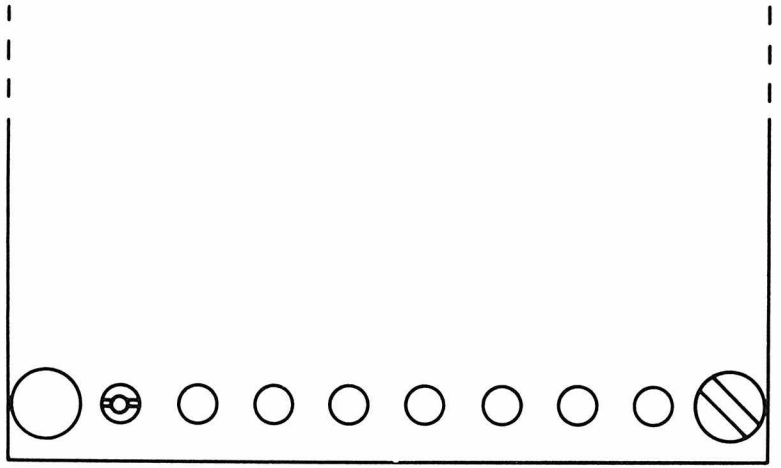


Exercise: PCB-5 (DRILLED)
Complete the drilled board of PCB-5 below.



TITLE PRINTED CIRCUIT BOARD—FLIP-FLOP (SINGLE SIDED)				DWG. NO. PCB-5	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 2 OF 3 / PAGE 49

Exercise: PCB-5 (ASSEMBLY)
Complete the assembly and list of material of PCB-5 below.



LIST OF MATERIAL

ITEM	NO. REQD.	REFERENCE DESIGNATION	DESCRIPTION	MANUFACTURER AND PART NUMBER OR MIL — TYPE DESIGNATION
1	X		SCHEMATIC	SHEET 1 OF 3
2		PCB-5		
3				

TITLE **PRINTED CIRCUIT BOARD** – FLIP-FLOP (SINGLE SIDED)

DWG. NO. **PCB-5**

NAME	DATE	COURSE	GRADE	SCALE	SHEET 3 OF 3	PAGE
				2 X SIZE		50

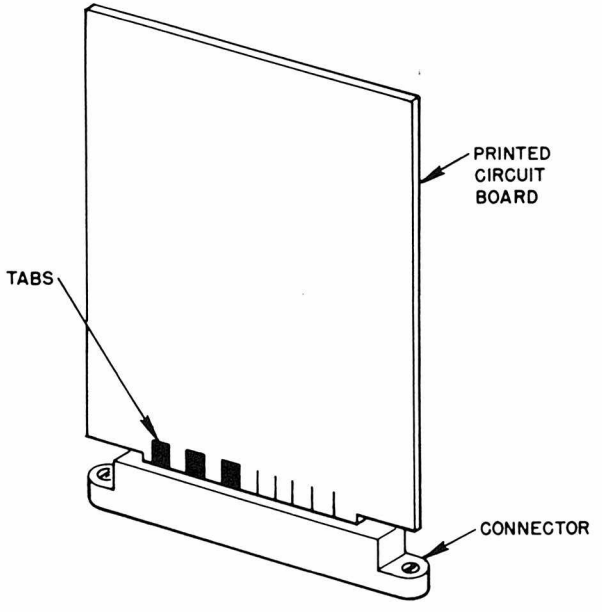
PRINTED CIRCUIT BOARD PCB-6.

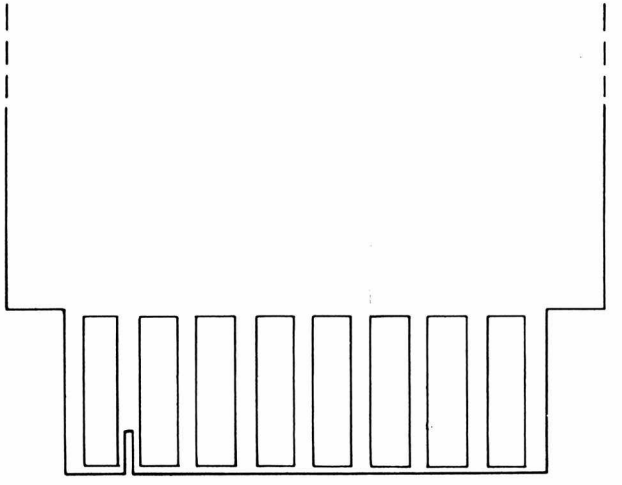
From the preceding schematic and the same list of material of PCB-5, prepare all the drawings required (four more) to fabricate a **double-sided PCB-6** (see PCB-4).

Exercise: (PCB-6)

Start with the layout below (2 × size). Make the length of the board layout as compact as possible, smaller than PCB-5. Use tabs in this fabrication so that the board can be plugged into a connector. No mounting screws are required. Spacing between components, land, conductors, etc., should be $\frac{1}{32}$ minimum ($\frac{1}{16}$ in 2 × size layout). Use the same data as in the preceding exercise (PCB-5). Identify this board as PCB-6.

A TYPICAL PLUG-IN
PRINTED CIRCUIT BOARD





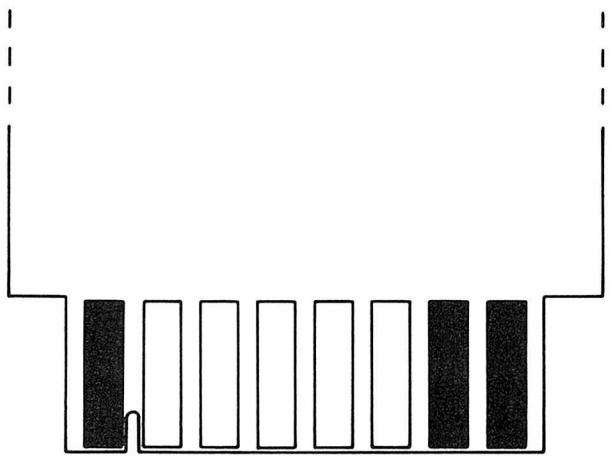
NOTES:
1. PCB TABS ARE ON ONE SIDE OF BOARD ONLY. (FRONT FACE)
2. FRONT FACE-SOLID LINES
   BACK FACE-HIDDEN LINES

TITLE					DWG. NO.
PRINTED CIRCUIT BOARD–FLIP-FLOP (DOUBLE SIDED)					PCB-6
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 1 OF 4 / PAGE 51

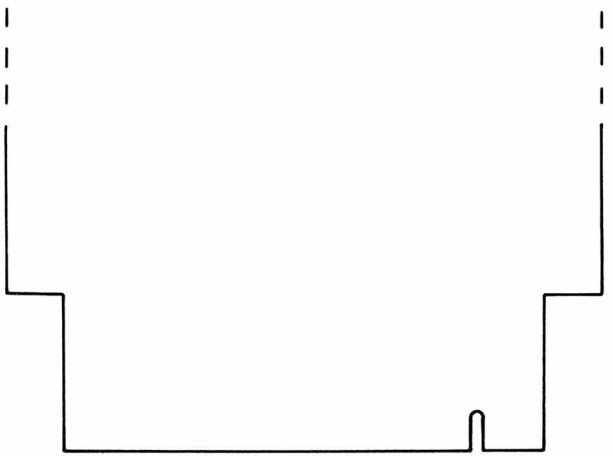
Exercise: PCB-6 (MASTER, ARTWORK)

Complete the two masters of PCB-6 below. Use either pencil or tapes, as instructed by your teacher.

FRONT FACE



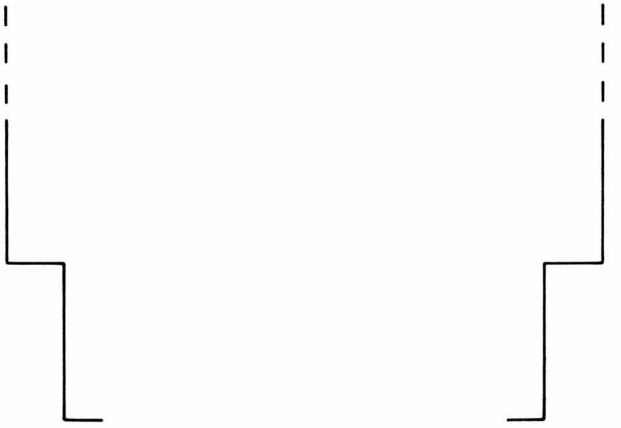
BACK FACE



TITLE PRINTED CIRCUIT BOARD – FLIP-FLOP (DOUBLE SIDED)					DWG. NO. PCB-6	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 2 OF 4	PAGE 52

Exercise: PCB-6 (DRILLED)

Complete the drilled board of PCB-6 below. Show all notes and hole chart (See PCB-4).

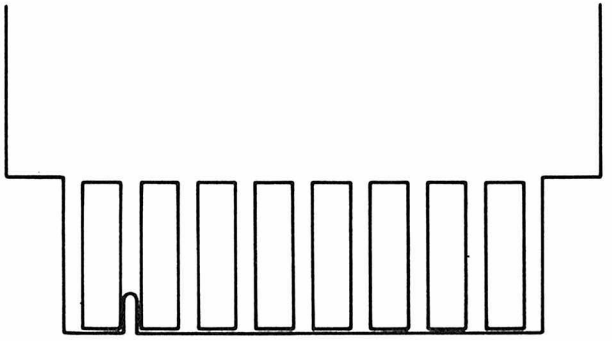


TITLE					DWG. NO.	
PRINTED CIRCUIT BOARD — FLIP-FLOP (DOUBLE SIDED)					PCB-6	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 3 OF 4	PAGE 53

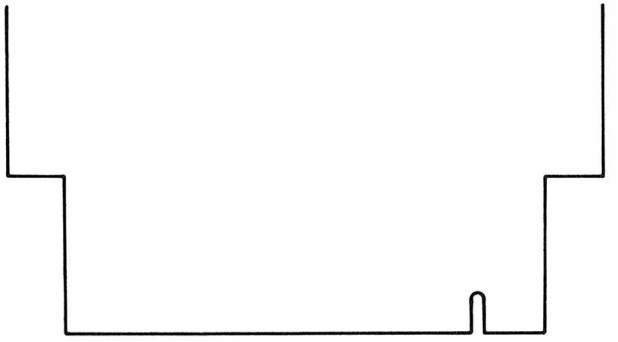
Exercise: PCB-6 (ASSEMBLY)

Complete the assembly of both sides (front and back) of PCB-6 below. Since this exercise has the same list of materials as PCB-5, it is not necessary to show it again. Draw only the components and outline of boards; do not show lands or conductors.

FRONT FACE



BACK FACE



TITLE					DWG. NO.	
PRINTED CIRCUIT BOARD – FLIP-FLOP (DOUBLE SIDED)					PCB-6	
NAME	DATE	COURSE	GRADE	SCALE 2 X SIZE	SHEET 4 OF 4	PAGE 54

INTRODUCTION: ELECTROMECHANICAL DESIGN

Basic steps needed in Electromechanical design are:

1. **Schematic diagram** (given to you in sketch form)
2. **Preliminary electrical parts list** (given)
3. **Layout** (done by you as designer)
4. **Detail drawings** (mechanical, from catalogues and/or direct measurements)
5. **Final assembly drawing** and **complete list of material**
6. **Wiring diagram** (both steps 5 and 6 done by you)

POWER SUPPLY DESIGN

Exercise. An electronics engineer wants you to design a simple package of the power supply given in the schematic shown in Fig. 1.

Solution. The first thing to do is to study the schematic. Then make a **preliminary electrical parts list** and **outline dimensions** of all the **components** given in the schematic.

Complete the preliminary electrical parts list by selecting the proper electrical components from Appendix B.

Next, devise a simple, neat, easy-to-build, serviceable package (continued on the next pages).

POWER SUPPLY SCHEMATIC DIAGRAM

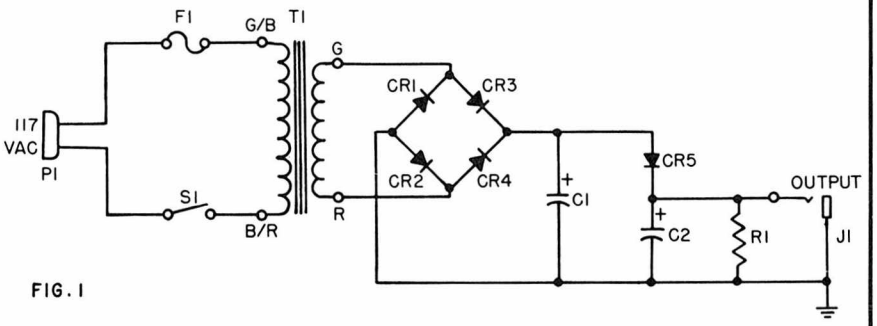


FIG. 1

Given:

Capacitor, C1 & C2 = 1500mfd, 50V
Diode, CR1 Thru CR5 = 1N91
Resistor, R1 = 22K, ½W, 5%
Transformer, T1 = TRIAD No. F-92A
Fuse, F1 = 1 amp, 125V (3 AG)
Toggle switch, S1 = MS35058-22
Output jack, J1 = Pin Jack Strip (two pins)
Power cord, P1 = any standard cord

PRELIMINARY ELECTRICAL PARTS LIST AND OUTLINE DIMENSIONS OF COMPONENTS

See Appendix B and complete the list below:

C1 and C2 = 1⅜ dia. × 3⅜ high (ARCO)

CR1 through CR5 —

P1 = ¼ O.D. cord

R1 = (RC20GF223J)

T1 =

F1 = (LITTELFUSE, INC.)

S1 =

J1 =

TITLE ELECTROMECHANICAL DESIGN – INTRODUCTION					DWG. NO. EMD-1	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 2	PAGE 55

ELECTROMECHANICAL DESIGN (cont.)

From your **preliminary electrical parts list** you will notice that transformer (T1) and capacitors (C1 and C2) are the largest components. One must select an enclosure or chassis large enough to house all the components and necessary hardware. This brings us to the third step — namely, the **layout.**

LAYOUT

The layout should describe the parts sufficiently for the detailer or a draftsman to understand what has been selected. Common screws or any other hardware may be written on the layout near the part for clarity.

The layout should be drawn accurately to scale. In this case we will use half scale. Other accessories which will be needed in our package will include the following:

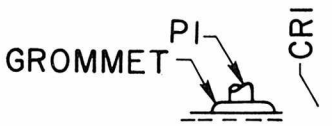
1. **Terminal board** (TB1) for mounting all diodes and resistor.
2. **Fuse holder** to house fuse (F1).
3. **Stand-offs, grommet, terminal lug, screws, nuts, washers,** etc.

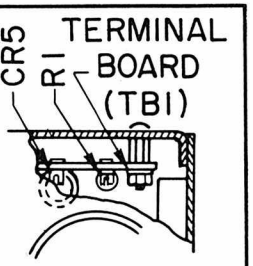
You will find that a **chassis** $5\frac{1}{2} \times 4\frac{3}{4} \times 1\frac{5}{16}$ would be large enough for our purpose.

Exercise. Complete the two views of the started layout on the right (scale: half size). Identify all components with reference designations. See Schematic. (Page 55)

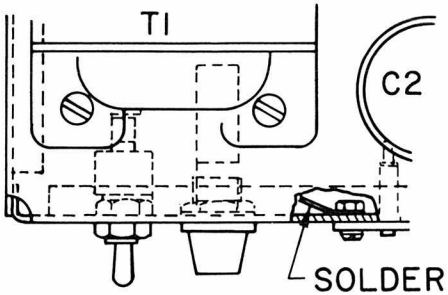
In general, additional information required for the design and/or details (such as **material for the chassis, finishes, specs,** etc.) are given in note form.

CHASSIS LAYOUT.



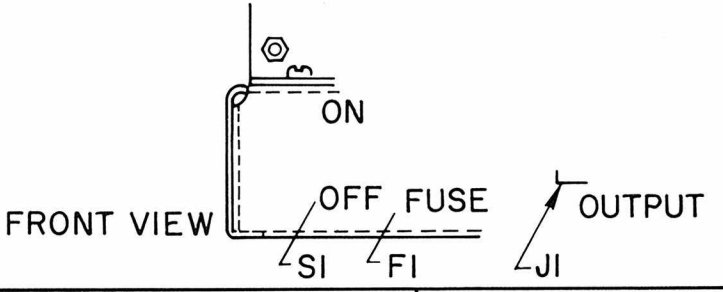


TOP VIEW



NOTES:

1. Material: alum sheet, $\frac{1}{16}$ thk. 6061-T6, per QQ-A-327, cond T.
2. Finish: alodine per MIL-C-5541 external surfaces and edges shall be painted gray.
3. Silk screen or rubber stamp letters on front, black.
4. No. 8-32 screws are used on T1 and J1. No. 4-40 screws and stand-offs are used on TB1.



TITLE					DWG. NO.	
ELECTROMECHANICAL DESIGN—LAYOUT					EMD-1	
NAME	DATE	COURSE	GRADE	SCALE 1/2	SHEET 2 OF 2	PAGE 56

ELECTROMECHANICAL DESIGN (cont.)

From the layout we proceed to the fourth step — namely, the **details.** The details are drawn by a draftsman or detailer from the layout. Detail parts should show dimensions, tolerance, etc. Whenever possible, for clarity, show the detail as large as space and standard scaling permit (e.g., 2/1 or 4/1). Use as many views and sections as are necessary to completely describe the part. It would be a good idea to detail the **terminal board** (TB1) before you detail the chassis.

Exercise: TERMINAL BOARD (TB1) DETAIL

From the layout you will notice that six components are mounted on the terminal board: five **diodes** and one **resistor.** That means that twelve **terminals** are required (two terminals per component).

Draw the terminal board full scale. Terminals are USECO No. 2000 B. (See Hardware, Appendix C, page 85). Show the board, terminals, and markings all in one detail.

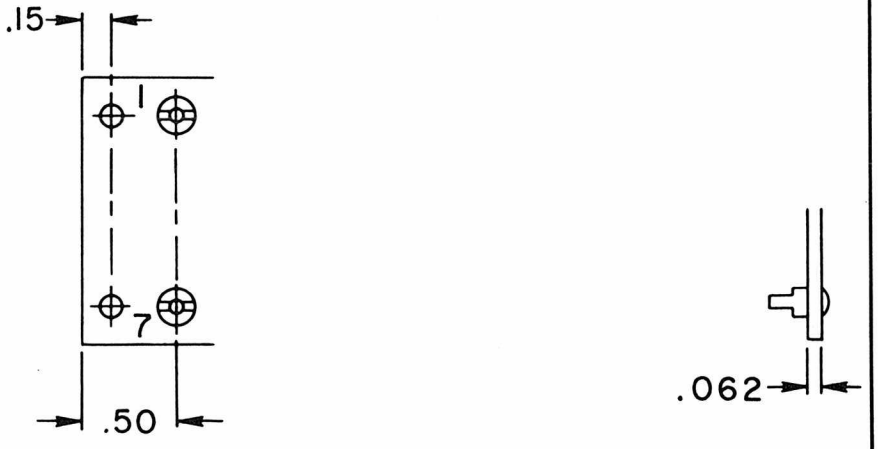
Board dimensions are 1.40 × 3.50 × .062 thick.

Terminal spacings are .50 and 1.00.

Dimension the terminal board according to standard practice as in Lesson 1, (Mechanical Drafting Review). Silk Screen or rubber stamp terminals from 1 through 12 as shown. Identify board TB1 parallel to right edge. In practical applications the drilling and marking details are done separately, but both details are combined here for simplicity.

After completing the details, proceed to the next page for **terminal board assembly.**

Exercise. Complete the two views of the terminal board below.



NOTES:

1. TERMINAL BOARD MATERIAL: .062 THK. PHENOLIC
2. SILK SCREEN OR RUBBER STAMP NUMBERS AND TERMINAL BOARD IDENTIFICATION (TBI) ⅛ HIGH, BLACK, BEFORE INSTALLING TERMINALS.
3. INSERT TERMINALS INTO BOARD AND SWAGE THEM OVER.

TITLE				DWG. NO.	
ELECTROMECHANICAL DESIGN–TERMINAL BOARD DETAIL				EMD-2	
NAME	DATE	COURSE	GRADE	SCALE	PAGE
				FULL	SHEET 1 OF 2	57

TERMINAL BOARD ASSEMBLY

The **assembly board** is drawn in the same manner as has been done in previous lessons. The only difference is that the Assembly here is drawn in two stages. This is sometimes called a **stage drawing.**

Stage 1. In this step, only the **board** and the **jumper wires** are shown. The terminals are connected with jumper wires. You will have to check this against the schematic and layout to determine which terminal will require the jumpers. Also show wires coming out of the board and identify the routes of these wires by assigning a **color code** to each. The color code will later help the technician to complete the wiring of the **power supply.** There are three wires coming out of the board:

From junction CR1, CR2, and R1, one wire (black)
From junction CR3, CR4, and CR5, one wire (red)
From junction R1 and CR5, one wire (green)

These wires should be at least 10″ long.

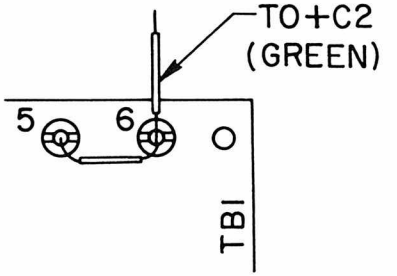
Stage 2. Draw the board again, but in this view show only the **electrical components** (CR1 through CR5 and R1). Show reference designations of all components. They should conform to those on the schematic diagram. With the assembly, include a list of material.

Note: If this board had been made into a **printed circuit board,** stage 1 would have been omitted. Due to the simplicity of the board, wires were used.

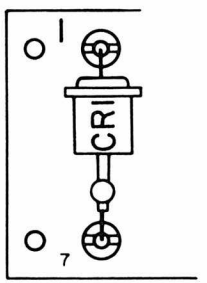
Complete the exercises on the right.

Exercise. Complete two stages and the list of material below.

Stage 1



Stage 2



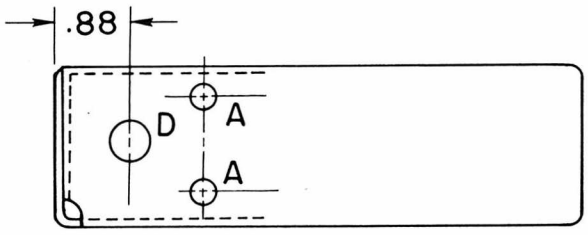
ITEM	NO. REQ'D	REF. DESIG.	DESCRIPTION	MANUFACTURER AND PART NO. OR MIL TYPE DESIGNATION
	AR		WIRE	AWG.22, PER MIL.-W-16878
	AR		SOLDER	PER QQ-S-571
	1		RESISTOR	
2		CR1-CR5		
1		TB1		

LIST OF MATERIAL

TITLE	DWG. NO.
ELECTROMECHANICAL DESIGN—TERM. BD. ASS'Y—STAGE DRAWINGS	EMD-2

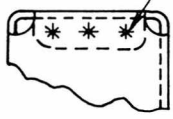
NAME	DATE	COURSE	GRADE	SCALE		PAGE
				FULL	SHEET 2 OF 2	58

Exercise. Complete the drawing of the **chassis** below showing three views (front, top, and back) plus Detail H (hole pattern for C1 and C2), and fill in **hole chart.** (See Lesson #1 for reviewing hole-pattern details). Scale: half size



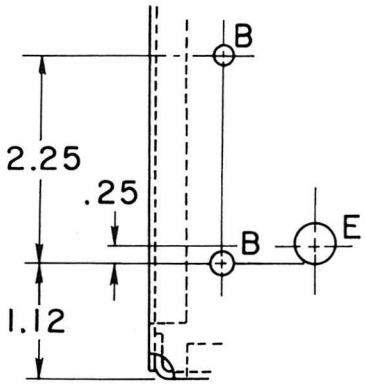
BACK VIEW

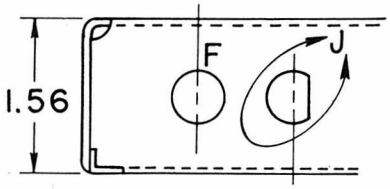
SPOT WELD FLANGES (TYP)



SIDE VIEW

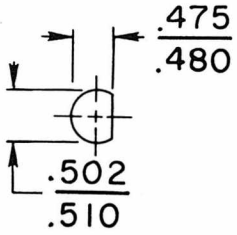
TOP VIEW





FRONT VIEW

HOLE CHART	
HOLE	DESCRIPTION
A	.125 DIA.
B	.180 DIA.
C	.250 DIA.
D	
E	
F	
G	.875 DIA.
H	SEE RECOMMENDED CHASSIS CUTOUT, PAGE 83. DRAW IT ABOVE DETAIL H AND 2 PLACES IN TOP VIEW.



DETAIL J

DETAIL H

NOTES:

1. MATERIAL; ALY SHEET 1/16 THK. PER QQ-A-327 6061-T6 COND T
2. FINISH: ALODINE PER MIL-C-5541.

EXTERNAL SURFACES TO BE PAINTED GREY.
SILK SCREEN OR RUBBER STAMP ALL IDENTIFICATIONS (ON, OFF, FUSE, OUTPUT)

TITLE ELECTROMECHANICAL DESIGN – CHASSIS DETAIL

DWG. NO. EMD-3

PAGE 59

SHEET 1 OF 1

SCALE 1/2

GRADE

COURSE

DATE

NAME

ASSEMBLY DRAWINGS

Assembly drawings should be drawn so that the detailed parts and **sub-assemblies** are shown in their relative position and scale with the number of views necessary to clearly portray the proper attachments. All detailed parts and sub-assemblies should be identified by an **item number** and, if an electrical part, by marking its **circuit designation** on the component. The item number should be placed in a $\frac{3}{8}$ diameter circle with a lead running from the circle to the part it identifies.

LIST OF MATERIAL

For each assembly drawing prepare a **list of material** and an **electrical parts list** containing all items which become part of the completed assembly, including (1), every item purchased or fabricated and (2), all material including finishes.

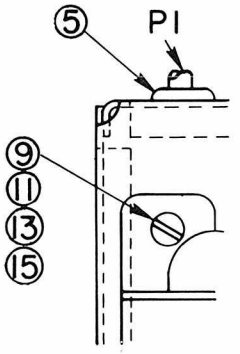
A subassembly which becomes part of the assembly should be listed as one item and identified by its drawing number (for example, the terminal board TB1). The list of material (hardware and fabricated parts) and the list of electrical parts should be prepared separately.

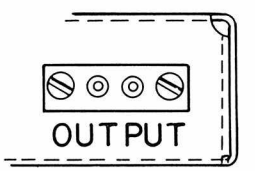
Exercise. Complete the **assembly drawing** on the right. If you made a good layout it could be used as the assembly drawing.

Show all items and identify the electrical components with **reference designations.** The reference designations of all electrical components should conform to those on the schematic diagram.

On the next page prepare separately, a list of material and an electrical parts list. For references use the schematic diagram, layout, and the appendixes.

The wiring diagram of the "power supply" will be drawn in Lesson 10 on wiring diagrams.





TITLE	ELECTROMECHANICAL DESIGN—ASSEMBLY DRAWING				DWG. NO. EMD-4	
NAME	DATE	COURSE	GRADE	SCALE 1/2	SHEET 1 OF 2	PAGE 60

Complete the List of Material and the Electrical Parts List below. Use the assembly drawing and appendixes for reference.

ITEM	NO. REQ'D	REF. DESIG	DESCRIPTION	MANUFACTURER AND PART NO. OR MIL TYPE DESIGNATION
10	AR		HOOKUP WIRE	AWG. 22, PER MIL-W-16878
9	AR		SOLDER SOFT	PER QQ-S-571
8		T1		TRIAD TRANSFORMER CORPORATION NO. F-92A
7	1		SWITCH TOGGLE	
6	1		PLUG AC	2 CONDUCTOR CORD, RUBBER-JACKETED AWG 18 (41 × 34) .245 O.D.
5	1	J1	JACK	
4			CAPACITOR ELECTROLYTIC	
3	1		FUSE	
2	X		SCHEMATIC DIAGRAM	EMD-1 Sheet 1 of 1
1	X		WIRING DIAGRAM	WD-2 Sheet 1 of 1 (Page 63)

ELECTRICAL PARTS LIST

ITEM	NO. REQ'D	DESCRIPTION	MANUFACTURER & PART NO. OR MIL TYPE DESIGNATION
15	6	WASHER, LOCK, SPLIT, NO. 8	
14	4	WASHER,	MS35337-78
13	6	WASHER,	MS15795-307
12	4	WASHER, FLAT, NO. 4, CRES	
11			MS35649-84
10	4		MS35649-44
9	4	SCREW, PAN HD. NO. 8-32 × 3/8 LONG	
8	2		MS35221-44
7	4		MS35221-18
6	1	SOLDER LUG (NO. 8)	
5	1		
4			
3	1		LITTELFUSE, INC. NO. 342001
2	1	TERMINAL BOARD ASSEMBLY (TB1)	EMD-2 SHEET 2
1		CHASSIS	EMD-3 SHEET 1

LIST OF MATERIAL

TITLE ELECTROMECHANICAL DESIGN-ELECTRICAL & MECHANICAL PARTS LIST

DWG. NO. EMD-4

PAGE 61

SHEET 2 OF 2

SCALE

GRADE

COURSE

DATE

NAME

INTRODUCTION: THE WIRING DIAGRAM

A **wiring diagram** (or connection diagram) shows pictorially, or in list form, the **wire connections** of an electronic assembly or its components. These connections may be external, internal, or both; however, the external-connection drawing is usually referred to as an **interconnection diagram.** An example shown in Fig. 1.

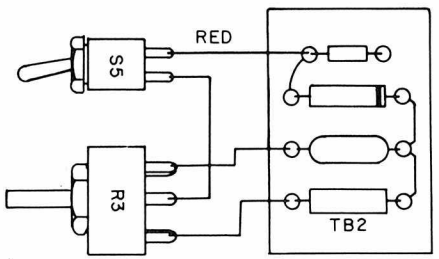


FIG. 1

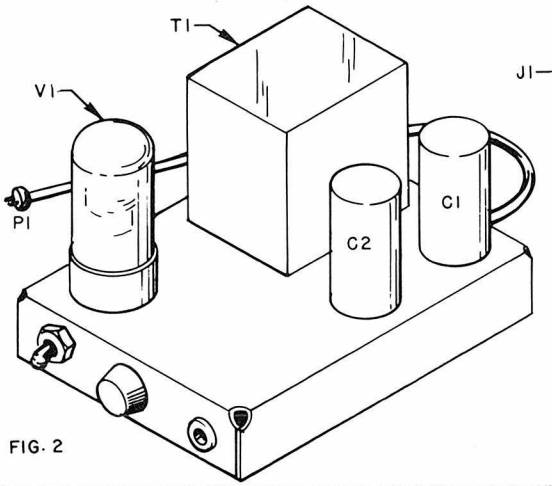


FIG. 2

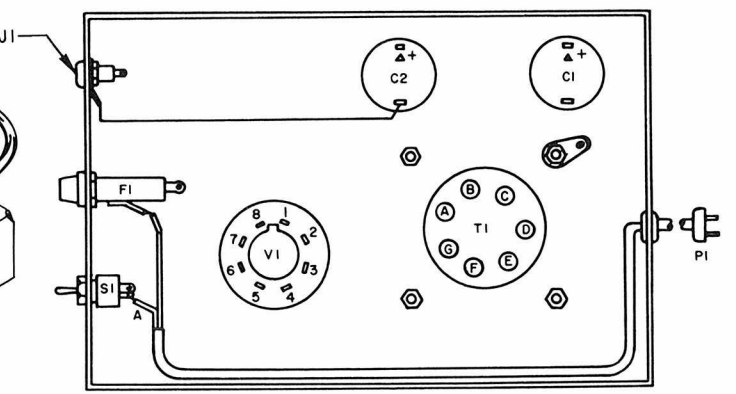
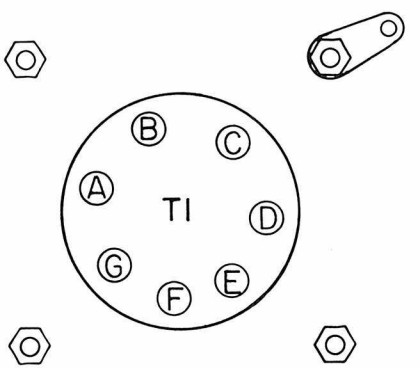


FIG. 3

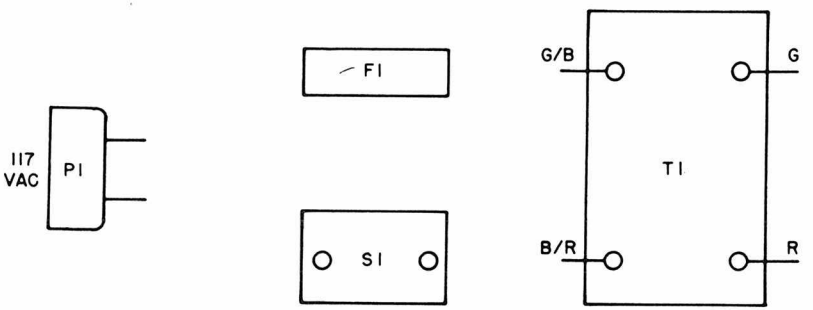
Exercise. Shown in Fig. 2 is the top view of the **power supply** in lesson 5, SCH-1 sheet 1 (page 25) Fig. 3 is the bottom view of the power supply.

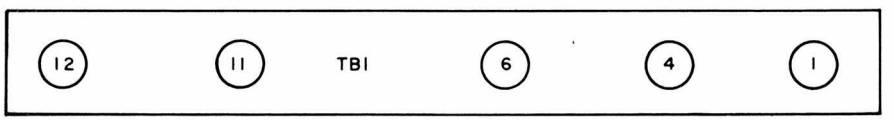
Redraw the bottom view of the power supply and show the wiring connections between all the components. For reference see schematic diagram of the power supply in SCH-1.



TITLE	WIRING DIAGRAM – INTRODUCTION				DWG. NO. WD-1	
NAME	DATE	COURSE	GRADE	SCALE NONE	SHEET 1 OF 1	PAGE 62

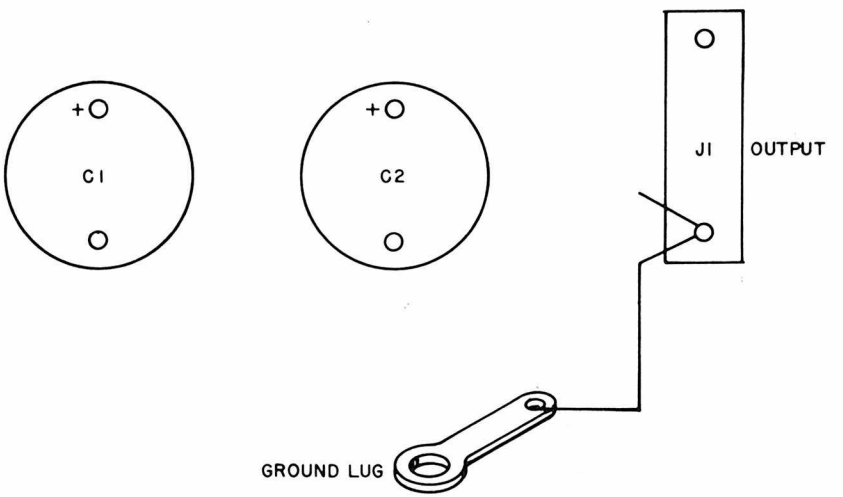
Exercise. Complete the started wiring diagram and wiring list of the power supply that you designed in the lesson on electromechanical design. Reference designations of the components should conform to those in the schematic diagram of the power supply (EMD-1, sheet 1, page 55). Notice that **blocks** are being used to represent component outlines. The **wiring list,** which is self-explanatory here, is commonly used in very complicated wiring diagrams.





WIRE			REF. NO.	FROM	TO
LENGTH INCHES	AWG	COLOR		LOCATION	LOCATION
	22	BLACK	1	P1	F1
			2		S1
		G/B	3	T1	F1
			4		
		G	5	T1	TB1-1
			6		
			7		
		RED	8	TB1-11	+ C1
			9		
			10		
			11		
			12	J1	GRD. LUG
	22		13		

ALL WIRES #22 AWG.



TITLE	WIRING DIAGRAM—POWER SUPPLY				DWG. NO. WD-2	
NAME	DATE	COURSE	GRADE	SCALE NONE	SHEET 1 OF 1	PAGE 63

INTRODUCTION: THE INTERCONNECTION DIAGRAM

An **interconnection diagram** is a drawing which shows the external wiring connections between items of equipment or unit assemblies. The internal connections of the unit assemblies are generally omitted.

In Fig. 1 is shown a typical audio system consisting of five units:

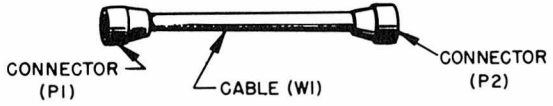
UNIT NO. 1: Record player
UNIT NO. 2: Tape recorder
UNIT NO. 3: Preamp
UNIT NO. 4: Power amplifier
UNIT NO. 5: Speaker

All these units are interconnected with cables numbered from W1 through W4. This audio system can be shown drawn as an **interconnection diagram** by drawing each unit as a **block** and each cable as a line, thus eliminating pictorial drawings.

A **unit** is identified by a unit number such as 1, 2, 3, etc.

A **cable** is identified with a W such as W1, W2, W3, etc.

The unit will always show the connector (jack) marked J1, J2, etc. Thus 2J1 means UNIT NO. 2, JACK NO. J1. The cables will be identified as shown:



Thus W1P1 means CABLE NO. W1, CONNECTOR NO. P1.

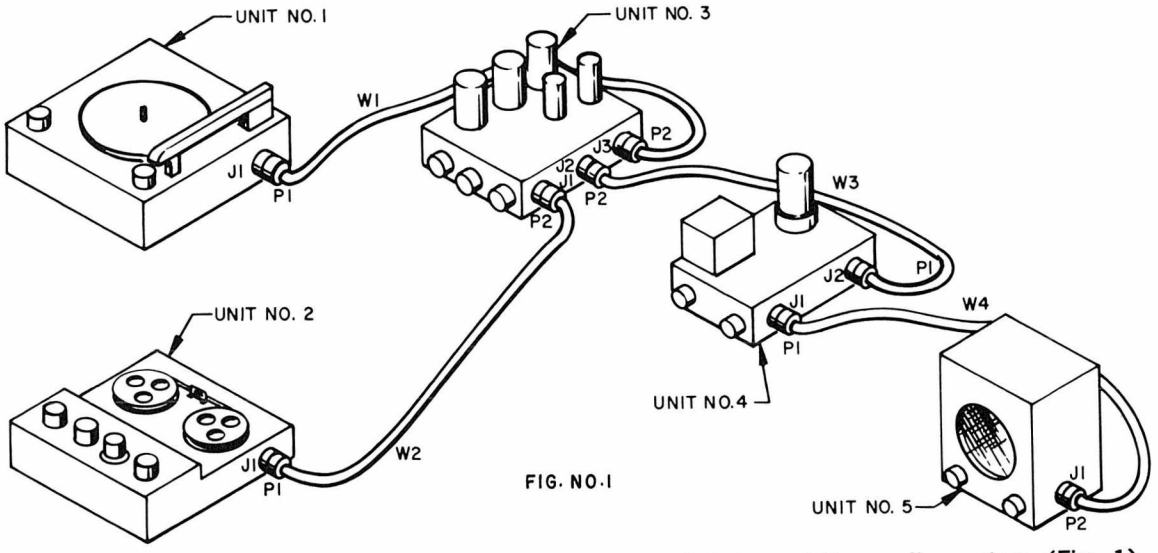
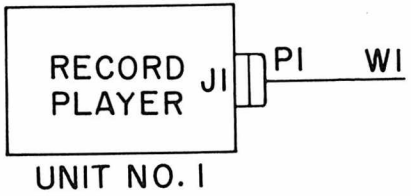


FIG. NO. 1

Exercise. Complete the **interconnection diagram** started below of the audio system (Fig. 1) by showing a single-line drawing identifying all **blocks, units, connectors,** and **cables.**



TITLE	INTERCONNECTION DIAGRAM – AUDIO SYSTEM				DWG. NO. ID-1	
NAME	DATE	COURSE	GRADE	SCALE NONE	SHEET 1 OF 1	PAGE 64

Exercise. Draw an **interconnection diagram** of a digital computer system and a list of routing of all cables without the help of a sketch. In more complicated interconnection diagrams, a list of cable routing is extremely helpful. The digital computer consists of the following nine units:

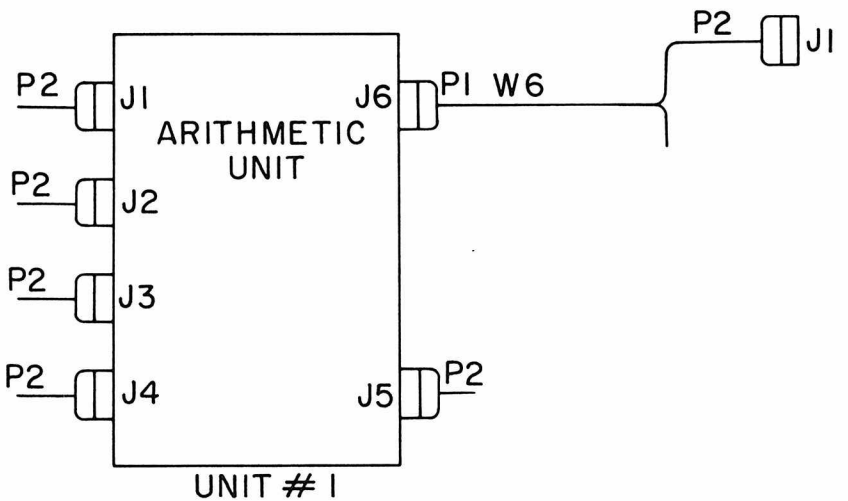
UNIT NO. 1: Arithmetic unit (6 jacks, J1 through J6)
UNIT NO. 2: Typewriter (1 jack, J1)
UNIT NO. 3: Tape recorder (1 jack, J1)
UNIT NO. 4: Card reader (1 jack, J1)
UNIT NO. 5: Plotter (1 jack, J1)
UNIT NO. 6: Power supply (1 jack, J1)
UNIT NO. 7: Core memory (1 jack, J1)
UNIT NO. 8: Disk storage (1 jack, J1)
UNIT NO. 9: Tape storage (1 jack, J1)

All the **units** from UNIT NO. 2 through 9 have one single **jack** (J1). UNIT NO. 1 has 6 JACKS numbered from J1 through J6 as shown. Show cable routing as follows;

From UNIT NO. 1 to UNIT NO. 2 J1 (CABLE NO. W1)
From UNIT NO. 1 to UNIT NO. 3 J1 (CABLE NO. W2)
From UNIT NO. 1 to UNIT NO. 4 J1 (CABLE NO. W3)
From UNIT NO. 1 to UNIT NO. 5 J1 (CABLE NO. W4)
From UNIT NO. 1 to UNIT NO. 6 J1 (CABLE NO. W5)
From UNIT NO. 1 to UNIT NO. 7 J1, UNIT NO. 8 J1, UNIT NO. 9 J1 (ONE SINGLE CABLE W6)

Complete the CABLE ROUTING LIST.

CABLE ROUTING	
FROM	TO
W1P1	2J1
W1P2	1J1
W6P4	7J1



TITLE		DWG. NO.
INTERCONNECTION DIAGRAM—DIGITAL COMPUTER SYSTEM		ID-2

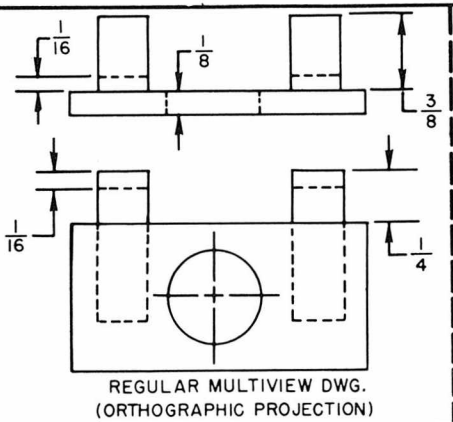
NAME	DATE	COURSE	GRADE	SCALE		PAGE
				NONE	SHEET 1 OF 1	65

PICTORIALS

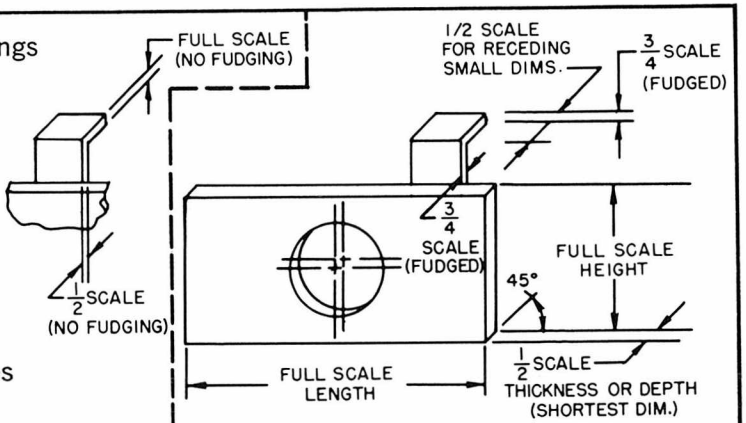
In most large companies, a technical illustrator does the "formal" **pictorials.** Smaller companies have their own draftsmen do them. But perhaps the most widespread function of the pictorial is its use in sketches between draftsmen, designers, and engineers to develop ideas. There are many types of pictorials. Probably the most common and easiest to draw are the **cabinet** and **isometric drawings.** These are illustrated at right. Neither the cabinet nor the isometric drawing is an accurate picture. Therefore a certain amount of "fudging" (guesswork and inaccurate touch-up) is acceptable.

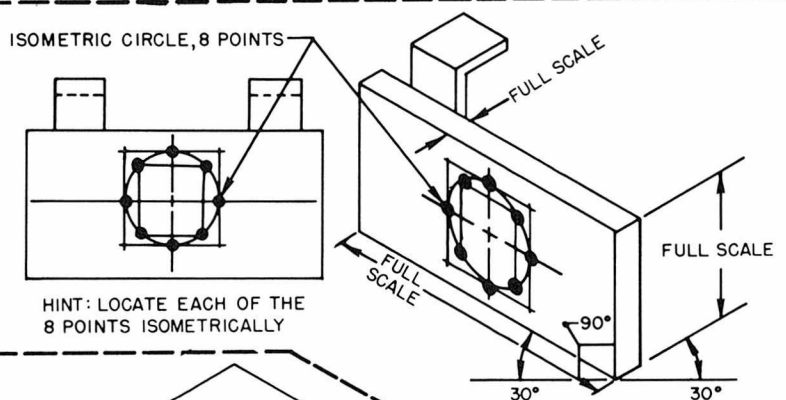
Exercise 1. Draw a second bracket on cabinet and isometric views (top and middle).

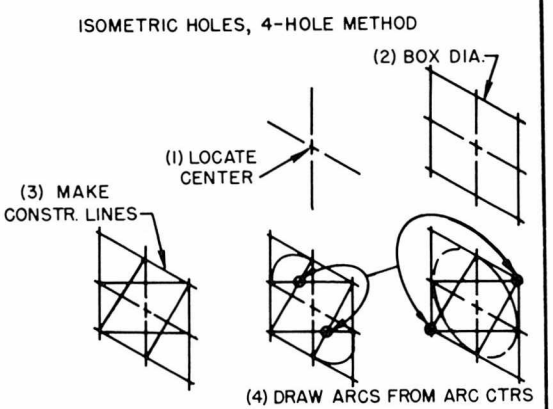
Exercise 2. In the isometric boxes at bottom right draw three 8-point circles in each surface center of box A and three 4-point center circles in each surface center of box B. Make all holes ½" diameter.

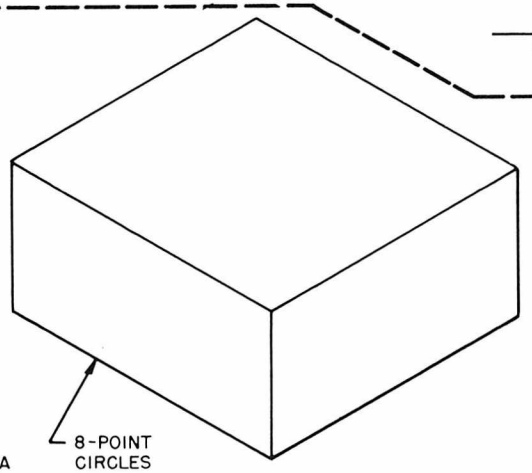


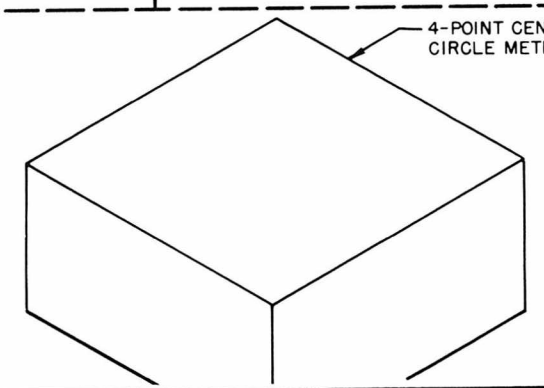
Cabinet drawings are basically made with **full scale length and height** but **half-scale depth,** with 45° **receding lines.** Fudging as shown reduces distortion.







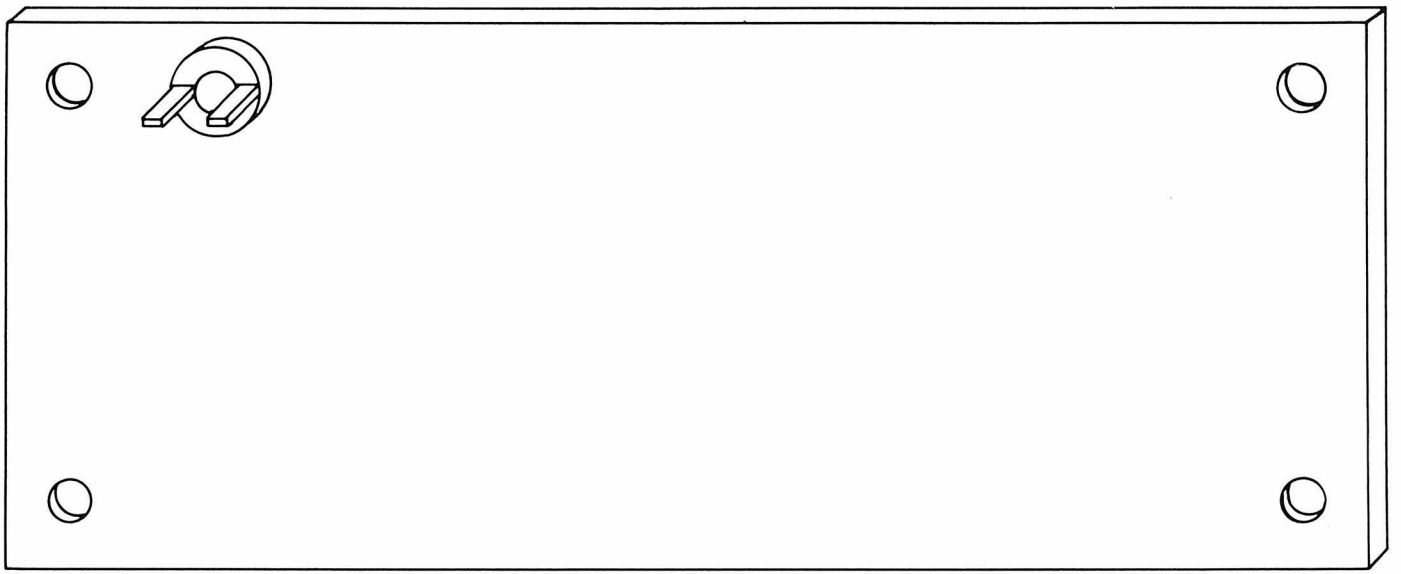




TITLE PICTORIALS—INTRODUCTION					DWG. NO. P-1	
NAME	DATE	COURSE	GRADE	SCALE	SHEET 1 OF 3	PAGE 66

From sheet 1 it was apparent that **cabinet drawings** lend themselves to relatively thin objects, while the boxlike subject shows up better in **isometric drawings.**

Exercise. Complete the cabinet drawing started below of the **terminal board assembly,** 2 X size. For reference see Electromechanical Design (lesson 9) sheets 1 and 2, pages 57 and 58. The terminals are USECO No. 2000B (Appendix C, page 85).



TITLE					DWG. NO.	
PICTORIALS – CABINET DRAWING – TERMINAL BOARD					P-1	
NAME	DATE	COURSE	GRADE	SCALE 2/1	SHEET 2 OF 3	PAGE 67

In **isometric drawings,** a cylinder can be drawn like a hole. Any curved line can be regarded as a portion of a circle and may be located by a series of points. In using a template (ellipse) for ISOMETRIC CIRCLES or curves, be sure to properly align the **major axis** of the ellipse so that it is 90° or at right angles to the **hole axis** (Fig. 1).

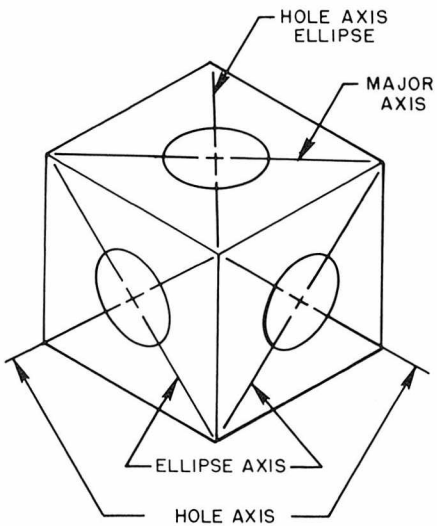
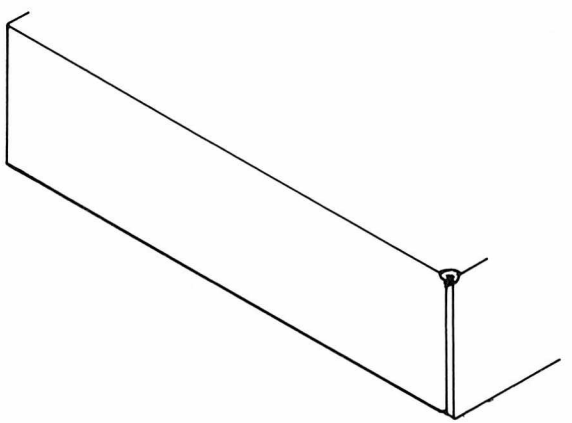


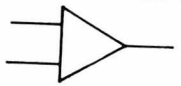
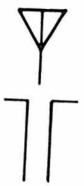
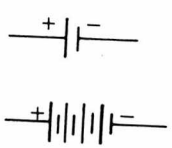
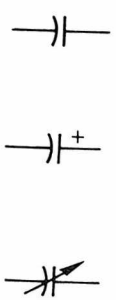
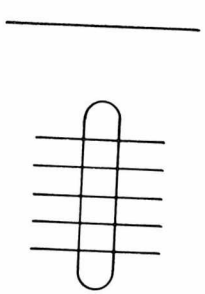
Fig. 1

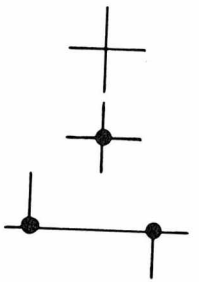
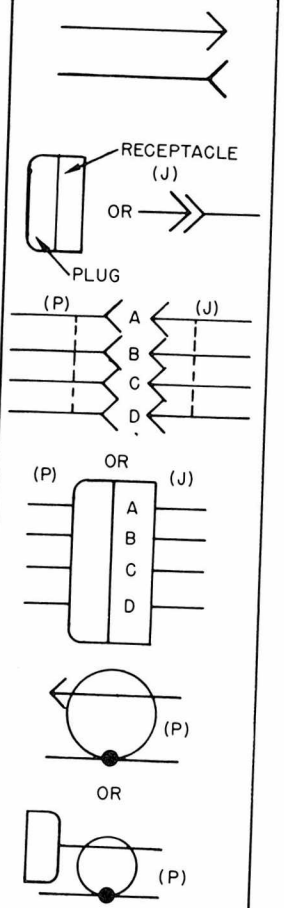
Exercise. Complete the **isometric** below. Draw the power supply of lesson 9, EMD-4 sheet 1 (page 60).

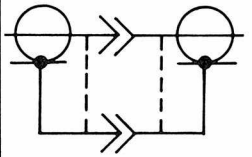
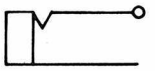
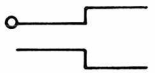
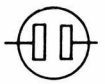
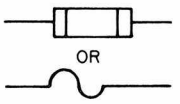


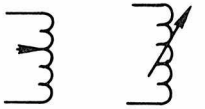
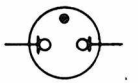
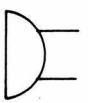
SCALE: HALF SIZE

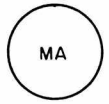
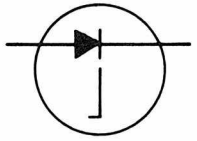
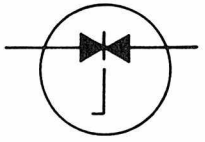
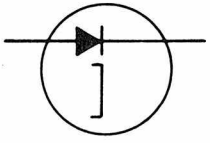
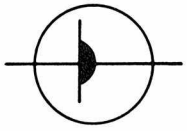
TITLE PICTORIALS—ISOMETRIC DRAWING					DWG. NO. P-1	
NAME	DATE	COURSE	GRADE	SCALE 1/2	SHEET 3 OF 3	PAGE 68

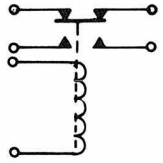
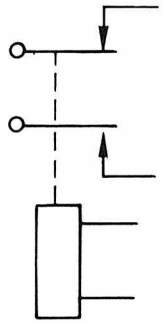
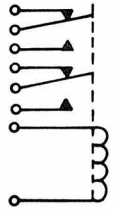
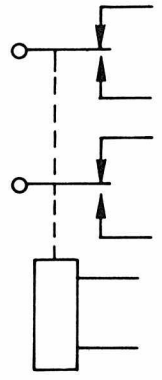
COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
AMPLIFIER Two inputs		AR	
ANTENNA General Dipole		E	
BATTERY One cell Multicell		BT	
CAPACITOR General Polarized (electrolytic) Variable or Adjustable		C	74 75, 83
CONDUCTOR Wiring (general) Cable, 1 or more conductors			

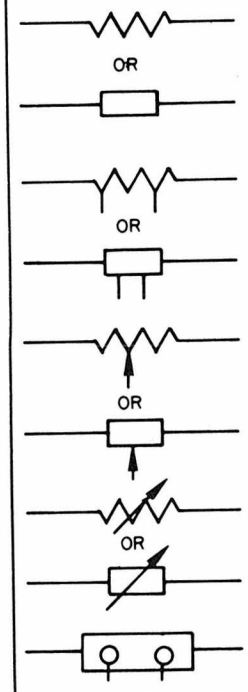
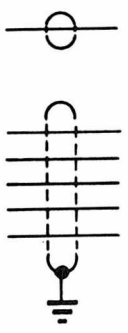
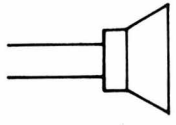
COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
Crossing not connected Junction (avoid if possible. Use next symbol) Junction			
CONNECTOR Male pin Female Socket Separable connectors (engaged) Engaged 4-conductor connectors. Letters or numerals need not be alphabetical or numerical in order. Coaxial, connector, build-up example. R-F connector (plug)		P J P P	

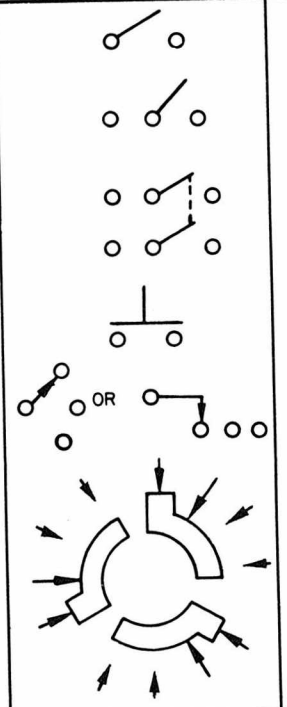
COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
CONNECTOR Mating coaxial			
Two-conductor (Jack)		J	
Two-conductor (Plug)		P	
Power, female contacts (2 conductors)			
Power, male contacts			
CRYSTAL Piezoelectric		Y	82
FUSE		F	82
GROUND Wire is bonded to chassis.			
Chassis or frame connection.			

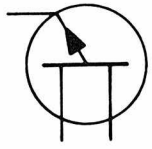
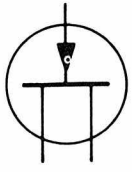
COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
INDUCTOR General		L	
Magnetic core			
Tapped			
Adjustable			
LAMP General		DS	
AC type, neon			
Incandescent filament			
MACHINE, ROTATING General		G	
Generator		B	
Motor			
MICROPHONE		MK	

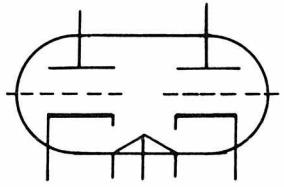
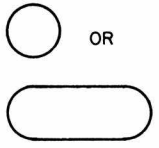
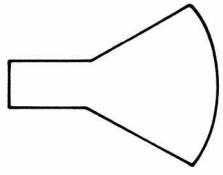
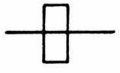
COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
METER (INSTRUMENTS) General		M	
Example: milliammeter			
RECTIFIER			
Semiconductor rectifier diode			76
Breakdown diode, unidirectional			
Breakdown diode, zener (old style)		CR	
Breakdown diode, bidirectional			76
Tunnel diode			76
Tunnel diode (old style)			

COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
RELAY			
Contactor (old style)			
Contactor		K	
Double-pole double-throw (DPDT) (old style)			
Double-pole double-throw (DPDT)			

COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
RESISTOR General Tapped Adjustable Variable Shunt		R	77, 78 79
SHIELDED CONDUCTOR Single conductor Five-conductor cable, shield grounded			
SPEAKER General		LS	

COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
SWITCH Single-Throw (ST) Double-throw (DT) Double-pole, Double-throw (DPDT) Push-button Selector Wafer, 3 poles, 3 circuits with 2 nonshorting and 1 shorting moving contacts.		S	79, 84
TERMINAL BOARD Group of 4 terminals		TB	
TRANSFORMER General Magnetic core Tapped		T	82

COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
TRANSISTOR			
PNP type			
PNP type with 1 electrode connected to envelope			
NPN type		Q	80
Unijunction N-type base			
Unijunction P-type base			
Field-effect N-type base			80

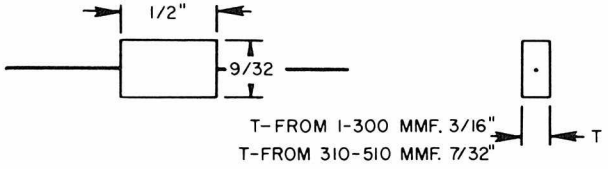
COMPONENT	SYMBOL	REF. DESIG.	APPENDIX B PAGE NO.
TUBE			
Triode		V	81
Twin triode			
TUBE ENVELOPE			
General			
Split			
Gas-filled			
C.R.T.			
WAVEGUIDE			
Circular		W	
Rectangular			

CAP. IN MMF.	MIL TYPE DESIGNATION	CAP. IN MMF.	MIL TYPE DESIGNATION
1	CM-15-C-010J	91	CM-15-E-910J
2	-C-020J	100	-E-101J
3	-C-030J	110	-E-111J
5	-C-050J	120	-E-121J
10	-C-100J	130	-E-131J
12	-C-120J	150	-E-151J
15	-C-150J	160	-E-161J
18	-C-180J	180	-E-181J
20	-C-200J	200	-E-201J
22	-C-220J	220	-E-221J
24	-E-240J	240	-E-241J
27	-E-270J	250	-E-251J
30	-E-300J	270	-E-271J
33	-E-330J	300	-E-301J
36	-E-360J	330	-E-331J
39	-E-390J	360	-E-361J
43	-E-430J	390	-E-391J
47	-E-470J	430	-E-431J
50	-E-500J	470	-E-471J
51	-E-510J	500	-E-501J
56	-E-560J	510	-E-511J
62	-E-620J	560	-E-561J
68	-E-680J	620	-E-621J
75	-E-750J	680	-E-681J
82	CM-15-E-820J	750	-E-751J
		820	CM-15-E-821J

COMPONENT:
CAPACITOR, MOLDED SILVERED MICA, 500 VDC, ±5% (MIL TYPE CM-15).

MANUFACTURER:
ARCO ELECTRONICS, INC.

COMPONENT OUTLINE:



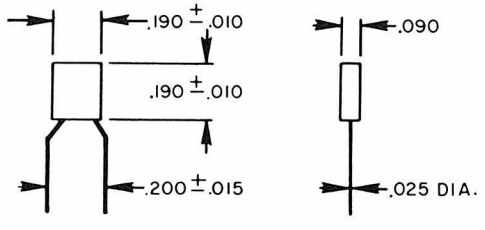
EXAMPLE:
240 MMF, 500V, ±5% = CM-15-E-241J
Capacitor dimensions = 3/16 X 9/32 X 1/2.

CAP. IN pf	MIL TYPE DESIGNATION	COMMERCIAL DESIGNATION
10	CK05CW100*	VK20CW100*
12	120*	120*
15	150*	150*
18	180*	180*
22	220*	220*
27	270*	270*
33	330*	330*
39	390*	390*
47	470*	470*
56	560*	560*
68	680*	680*
82	820*	820*
100	101*	101*
120	121*	121*
150	151*	151*
180	181*	181*
220	221*	221*
270	271*	271*
330	331*	331*
390	391*	391*
470	471*	471*
560	561*	561*
680	681*	681*
820	821*	821*
1000	CK05CW102*	VK20CW102*

COMPONENT:
CAPACITOR, MICROMINIATURE, CERAMIC, 200 VDC, (MIL TYPE CK05).
*J = ±5%, K = ±10%, M = ±20%.

MANUFACTURER:
VITRAMON, INC.

COMPONENT OUTLINE:

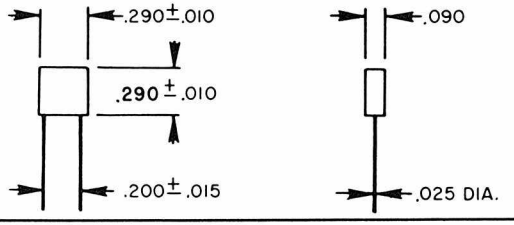


CAP. IN pf	MIL TYPE DESIGNATION	COMMERCIAL DESIGNATION
1200	CK06CW122*	VK30CW122*
1500	152*	152*
1800	182*	182*
2200	222*	222*
2700	272*	272*
3300	332*	332*
3900	392*	392*
4700	472*	472*
5600	562*	562*
6800	682*	682*
8200	822*	822*
10000	CK06CW103*	VK30CW103*

COMPONENT:
CAPACITOR, MICROMINIATURE, CERAMIC, 200 VDC, (MIL TYPE CK06).
*J = ±5%, K = ±10%, M = ±20%.

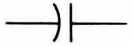
MANUFACTURER:
VITRAMON, INC.

COMPONENT OUTLINE:



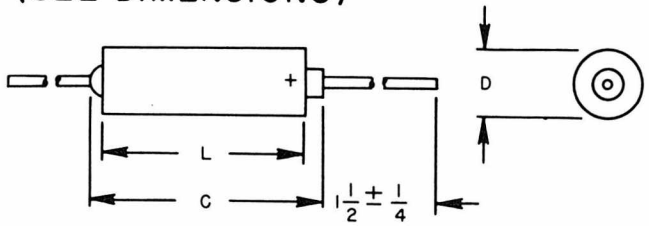
COMPONENT:
CAPACITOR–GENERAL PURPOSE, MIL TYPE, CM-15
CK05
CK06

NOTE:
MMF IS THE SAME AS pf.

SYMBOL	REF. DESIG.
	C

CAPACITANCE IN MFD.	DC RATED VOLTAGE	CASE SIZE	MIL TYPE DESIGNATION
5.6	6	A	CS13AB5R6K
6.8	6	A	AB6R8K
47	6	B	AB470K
56	6	B	AB560K
150	6	C	AB151K
180	6	C	AB181K
270	6	D	AB271K
330	6	D	AB331K
3.9	10	A	AC3R9K
4.7	10	A	AC4R7K
27	10	B	AC270K
33	10	B	AC330K
39	10	B	AC390K
82	10	C	AC820K
100	10	C	AC101K
120	10	C	AC121K
180	10	D	AC181K
220	10	D	AC221K
2.7	15	A	AD2R7K
3.3	15	A	AD3R3K
18	15	B	AD180K
22	15	B	AD220K
56	15	C	AD560K
68	15	C	AD680K
120	15	D	AD121K
150	15	D	AD151K
1.2	20	A	AE1R2K
1.5	20	A	CS13AE1R5K
1.8	20	A	CS13AE1R8K
2.2	20	A	AE2R2K
8.2	20	B	AE8R2K
10	20	B	AE100K
12	20	B	AE120K
15	20	B	AE150K
27	20	C	AE270K
33	20	C	AE330K
39	20	C	AE390K
47	20	C	AE470K
56	20	D	AE560K
68	20	D	AE680K
82	20	D	AE820K
100	20	D	AE101K
0.33	35	A	AFR33K
0.39	35	A	AFR39K
0.47	35	A	AFR47K
0.56	35	A	AFR56K
0.68	35	A	AFR68K
0.82	35	A	AFR82K
1	35	A	AF010K
1.2	35	B	AF1R2K
1.5	35	B	AF1R5K
1.8	35	B	AF1R8K
2.2	35	B	AF2R2K
2.7	35	B	AF2R7K
3.3	35	B	AF3R3K
3.9	35	B	AF3R9K
4.7	35	B	AF4R7K
5.6	35	B	CS13AF5R6K
6.8	35	B	CS13AF6R8K
8.2	35	C	AF8R2K
10	35	C	AF100K
12	35	C	AF120K
15	35	C	AF150K
18	35	C	AF180K
22	35	C	AF220K
27	35	D	AF270K
33	35	D	AF330K
39	35	D	AF390K
47	35	D	AF470K
1	50	A	AG010K
1.2	50	B	AG1R2K
1.5	50	B	AG1R5K
1.8	50	B	AG1R8K
2.2	50	B	AG2R2K
2.7	50	B	AG2R7K
3.3	50	B	AG3R3K
3.9	50	B	AG3R9K
4.7	50	B	AG4R7K
5.6	50	C	AG5R6K
6.8	50	C	AG6R8K
8.2	50	C	AG8R2K
10	50	C	AG100K
12	50	C	AG120K
15	50	C	AG150K
18	50	C	AG180K
22	50	D	CS13AG220K

COMPONENT OUTLINE (SEE DIMENSIONS)

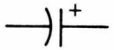


EXAMPLE:

0.68 MFD.35V, ±10% = Mil No. CS13AFR68K
For Capacitor Dimensions see Case A

CAPACITOR DIMENSIONS

CASE SIZE	C max	D $^{0+.016}_{-0.015}$	L±0.031	LEAD DIAMETER $^{+0.005}_{-0.001}$
A	0.422	0.135	0.286	0.020
B	0.610	0.185	0.474	0.020
C	0.822	0.289	0.686	0.025
D	0.922	0.351	0.786	0.025

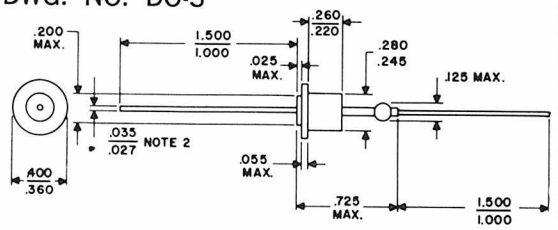
SYMBOL 

COMPONENT
CAPACITOR, FIXED, SOLID ELECTROLYTE, TANTALUM, MIL TYPE CS13 (±10%)

REF. DESIG.
C

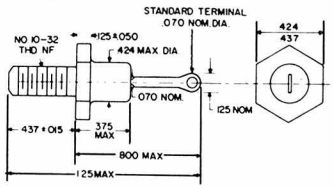
DIODE OUTLINE DWG. NO.

DWG. NO. DO-3



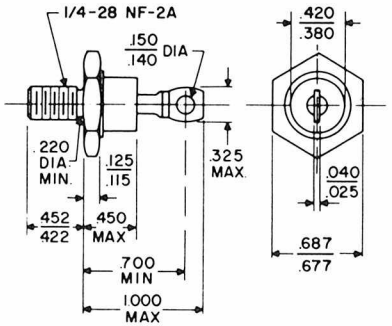
DIODE SYMBOL

DWG. NO. DO-4



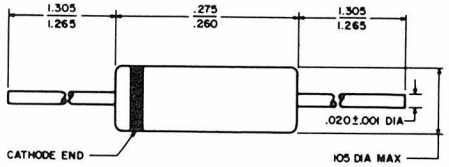
DIODE SYMBOL

DWG. NO. DO-5



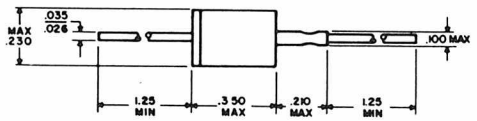
DIODE SYMBOL

DWG. NO. DO-7

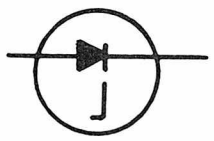


DIODE SYMBOL

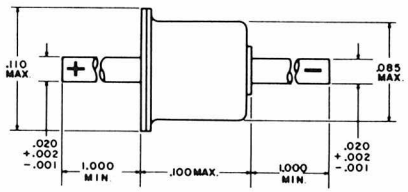
DWG. NO. DO-13



DIODE SYMBOL



DWG. NO. A.



DIODE SYMBOL

DIODE TYPE NUMBER	DIODE TYPE NUMBER	DIODE DWG. NO.	MANUFACTURER'S NAME
1N91	1N93	DO-3	GENERAL ELECTRIC
1N92		DO-3	GENERAL ELECTRIC
1N550	1N553	DO-4	GENERAL ELECTRIC
1N551	1N554	DO-4	GENERAL ELECTRIC
1N552	1N555	DO-4	GENERAL ELECTRIC
1N2155	1N2157	DO-5	GENERAL ELECTRIC
1N2154	1N2156	DO-5	GENERAL ELECTRIC
1N3064	1N3600	DO-7	GENERAL ELECTRIC
1N3604	1N3605	DO-7	GENERAL ELECTRIC
1N3606		DO-7	GENERAL ELECTRIC
1N483A	1N617	DO-7	HUGHES
1N1765	1N1776	DO-13	GENERAL ELECTRIC
1N3712	1N3714	A	GENERAL ELECTRIC
1N3713	1N3715	A	GENERAL ELECTRIC

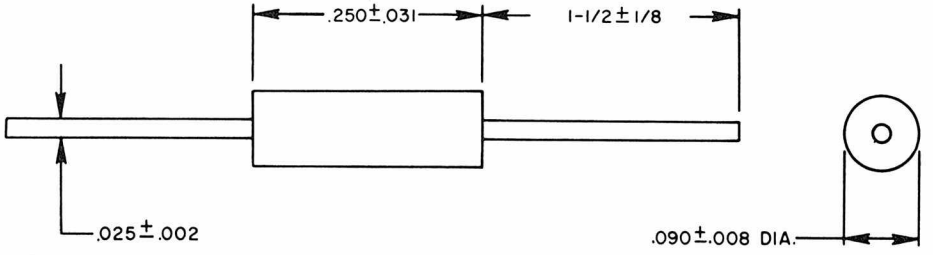
NOTE:

Blank spaces can be filled in by either teacher or student with additional diodes he may need as reference material.

REF. DESIG.	COMPONENT:
CR	RECTIFIER, DIODE

Total Resistance Ohms	MIL Type Designation	Total Resistance Ohms	MIL Type Designation	Total Resistance Ohms	MIL Type Designation	Total Resistance Ohms	MIL Type Designation	Total Resistance Megohms	MIL Type Designation
10	RC07GF100J	180	RC07GF181J	3,300	RC07GF332J	56,000	RC07GF563J	1.0	RC07GF105J
11	110J	200	201J	3,600	362J	62,000	623J	1.1	115J
12	120J	220	221J	3,900	392J	68,000	683J	1.2	125J
13	130J	240	241J	4,300	432J	75,000	753J	1.3	135J
15	150J	270	271J	4,700	472J	82,000	823J	1.5	155J
16	160J	300	301J	5,100	512J	91,000	913J	1.6	165J
18	180J	330	331J	5,600	562J	100,000	104J	1.8	185J
20	200J	360	361J	6,200	622J	110,000	114J	2.0	205J
22	220J	390	391J	6,800	682J	120,000	124J	2.2	225J
24	240J	430	431J	7,500	752J	130,000	134J	2.4	245J
								2.7	275J
27	270J	470	471J	8,200	822J	150,000	154J	3.0	305J
30	300J	510	511J	9,100	912J	160,000	164J	3.3	335J
33	330J	560	561J	10,000	103J	180,000	184J	3.6	365J
36	360J	620	621J	11,000	113J	200,000	204J	3.9	395J
39	390J	680	681J	12,000	123J	220,000	224J	4.3	435J
43	430J	750	751J	13,000	133J	240,000	244J	4.7	475J
47	470J	820	821J	15,000	153J	270,000	274J	5.1	515J
51	510J	910	911J	16,000	163J	300,000	304J	5.6	565J
56	560J	1,000	102J	18,000	183J	330,000	334J	6.2	625J
62	620J	1,100	112J	20,000	203J	360,000	364J	6.8	685J
								7.5	755J
68	680J	1,200	122J	22,000	223J	390,000	394J	8.2	825J
75	750J	1,300	132J	24,000	243J	430,000	434J	9.1	915J
82	820J	1,500	152J	27,000	273J	470,000	474J	10.0	106J
91	910J	1,600	162J	30,000	303J	510,000	514J	11	116J
100	101J	1,800	182J	33,000	333J	560,000	564J	12	126J
110	111J	2,000	202J	36,000	363J	620,000	624J	13	136J
120	121J	2,200	222J	39,000	393J	680,000	684J	15	156J
130	131J	2,400	242J	43,000	433J	750,000	754J	16	166J
150	151J	2,700	272J	47,000	473J	820,000	824J	18	186J
160	RC07GF161J	3,000	RC07GF302J	51,000	RC07GF513J	910,000	RC07GF914J	20	206J
								22	RC07GF226J

COMPONENT OUTLINE



COMPONENT

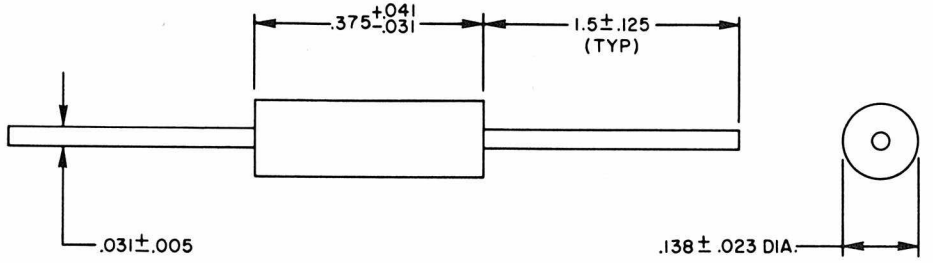
RESISTOR, FIXED, COMPOSITION
1/4 WATT ±5% (MIL STYLE RC07)

SYMBOL

REF. DESIG.
R

Total Resistance Ohms	MIL Type Designation	Total Resistance Ohms	MIL Type Designation	Total Resistance Ohms	MIL Type Designation	Total Resistance Ohms	MIL Type Designation	Total Resistance Megohms	MIL Type Designation
10	RC20GF100J	180	RC20GF181J	3,300	RC20GF332J	56,000	RC20GF563J	1.0	RC20GF105J
11	110J	200	201J	3,600	362J	62,000	623J	1.1	115J
12	120J	220	221J	3,900	392J	68,000	683J	1.2	125J
13	130J	240	241J	4,300	432J	75,000	753J	1.3	135J
15	150J	270	271J	4,700	472J	82,000	823J	1.5	155J
16	160J	300	301J	5,100	512J	91,000	913J	1.6	165J
18	180J	330	331J	5,600	562J	100,000	104J	1.8	185J
20	200J	360	361J	6,200	622J	110,000	114J	2.0	205J
22	220J	390	391J	6,800	682J	120,000	124J	2.2	225J
24	240J	430	431J	7,500	752J	130,000	134J	2.4	245J
								2.7	275J
27	270J	470	471J	8,200	822J	150,000	154J	3.0	305J
30	300J	510	511J	9,100	912J	160,000	164J	3.3	335J
33	330J	560	561J	10,000	103J	180,000	184J	3.6	365J
36	360J	620	621J	11,000	113J	200,000	204J	3.9	395J
39	390J	680	681J	12,000	123J	220,000	224J	4.3	435J
43	430J	750	751J	13,000	133J	240,000	244J	4.7	475J
47	470J	820	821J	15,000	153J	270,000	274J	5.1	515J
51	510J	910	911J	16,000	163J	300,000	304J	5.6	565J
56	560J	1,000	102J	18,000	183J	330,000	334J	6.2	625J
62	620J	1,100	112J	20,000	203J	360,000	364J	6.8	685J
								7.5	755J
68	680J	1,200	122J	22,000	223J	390,000	394J	8.2	825J
75	750J	1,300	132J	24,000	243J	430,000	434J	9.1	915J
82	820J	1,500	152J	27,000	273J	470,000	474J	10.0	106J
91	910J	1,600	162J	30,000	303J	510,000	514J	11	116J
100	101J	1,800	182J	33,000	333J	560,000	564J	12	126J
110	111J	2,000	202J	36,000	363J	620,000	624J	13	136J
120	121J	2,200	222J	39,000	393J	680,000	684J	15	156J
130	131J	2,400	242J	43,000	433J	750,000	754J	16	166J
150	151J	2,700	272J	47,000	473J	820,000	824J	18	186J
160	RC20GF161J	3,000	RC20GF302J	51,000	RC20GF513J	910,000	RC20GF914J	20	206J
								22	RC20GF226J

COMPONENT OUTLINE



COMPONENT

RESISTOR, FIXED, COMPOSITION
1/2 WATT ± 5% (MIL STYLE RC20)

SYMBOL

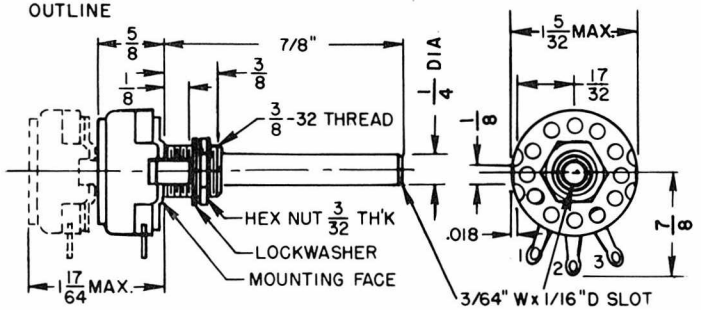
REF. DESIG.

R

RESISTANCE IN OHMS	MIL TYPE DESIGNATION	RESISTANCE IN OHMS	MIL TYPE DESIGNATION
50	RV4NAYSD500A*	25000	RV4NAYSD253A*
100	101A	35000	353A
150	151A	50000	503A
250	251A	75000	753A
350	351A	.1 meg.	104A
500	501A	.15 meg.	154A
750	751A	.25 meg.	254A
1000	102A	.35 meg.	354A
1500	152A	.5 meg.	504A
2500	252A	.75 meg.	754B*
3500	352A	1.0 meg.	105B
5000	502A	1.5 meg.	155B
7500	752A	2.0 meg.	205B
10000	103A	2.5 meg.	255B
15000	RV4NAYSD153A	3.5 meg.	355B
		5.0 meg.	RV4NAYSD505B

*A = 10% B = 20%

COMPONENT OUTLINE



ROUND TYPE SHAFT
FOR 1/4" PANEL MAX.

EXAMPLE:

POTENTIOMETER, 35K, 2 WATTS, ±10%
NO. = RV4NAYSD353A.

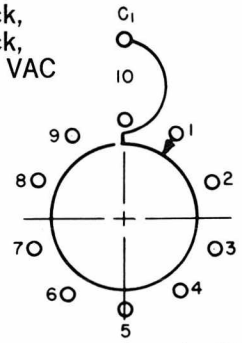
MANUFACTURER	SYMBOL	REF. DESIG.
OHMITE MANUFACTURING CO.		R

COMPONENT	
POTENTIOMETER (VARIABLE RESISTOR)	(2 WATTS)

COMPONENT:

MIL-TAP SWITCH,
Rating;
1 to 10 decks,
2 to 10 Pos. per deck,
1 or 2 poles per deck,
Break 1 Amp. 115 VAC

SYMBOL

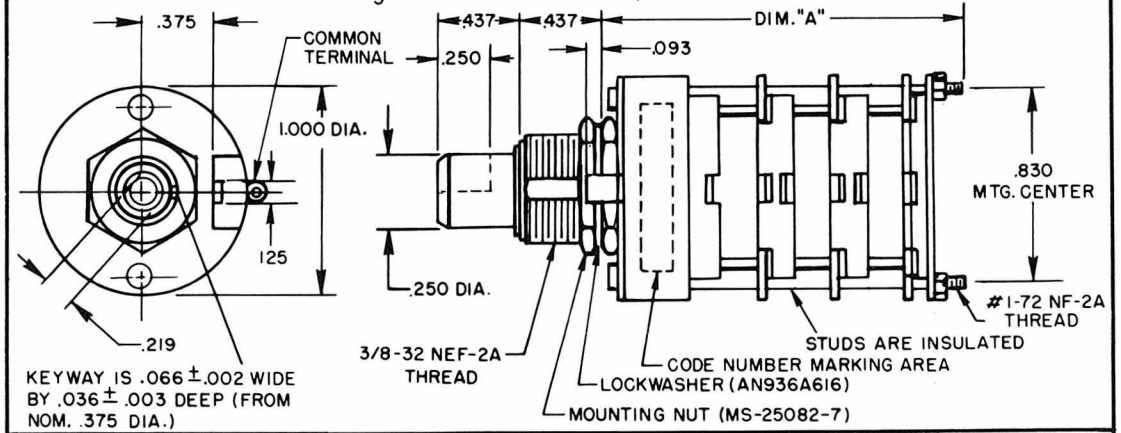


NO. OF DECKS	DIM. "A"	NO. OF POSITIONS PER DECK		
		2	3	4
1	1.02"	24801-2	24801-3	24801-4
2	1.39"	24802-2	24802-3	24802-4
3	1.77"	24803-2	24803-3	24803-4
4	2.14"	24804-2	24804-3	24804-4
5	2.52"	24805-2	24805-3	24805-4
6	2.89"	24806-2	24806-3	24806-4
7	3.27"	24807-2	24807-3	24807-4
8	3.64"	24808-2	24808-3	24808-4
9	4.06"	24809-2	24809-3	24809-4
10	4.39"	24810-2	24810-3	24810-4

EXAMPLE:

1 Amp., 115 VAC. MIL-TAP SWITCH,
3 DECK, 4 POSITIONS = NO. 24803-4

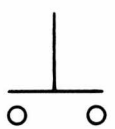
COMPONENT OUTLINE



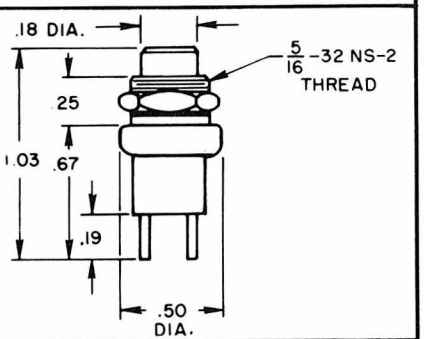
COMPONENT

MOMENTARY SWITCH, (SPST)
PUSH BUTTON,
¼ AMP, 115 VAC.
SWITCH NO. 23-1

SYMBOL



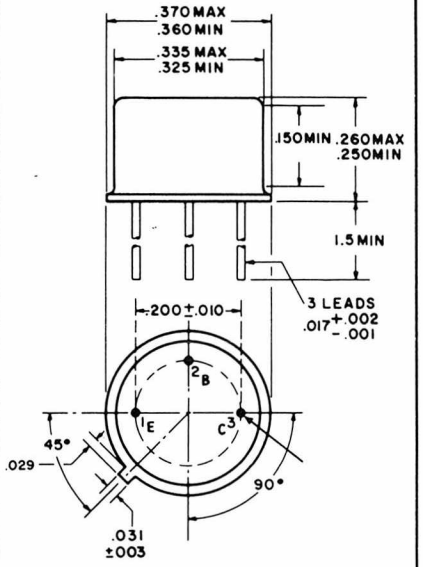
COMPONENT OUTLINE



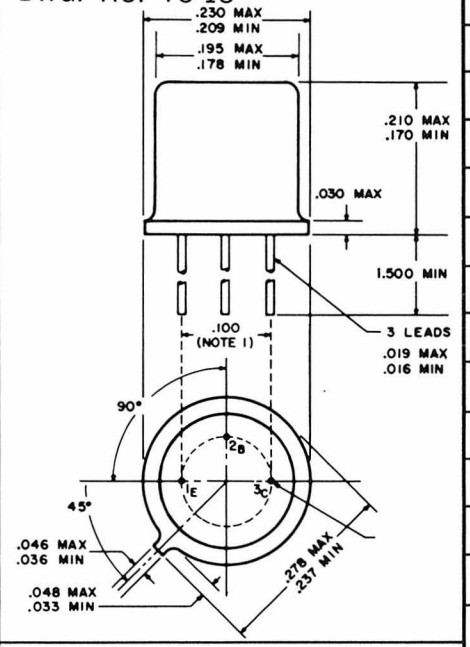
MANUFACTURER	REF. DESIG.	COMPONENT
GRAYHILL INC.	S	SWITCH

TRANSISTOR OUTLINE
DWG. NO.

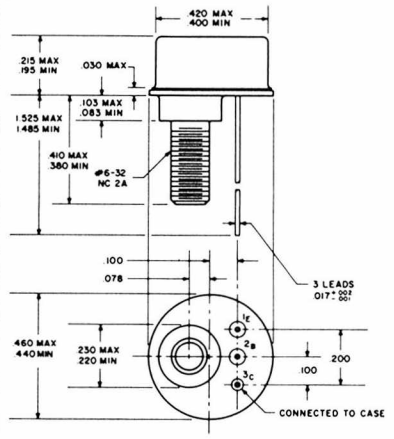
DWG. NO. TO-5



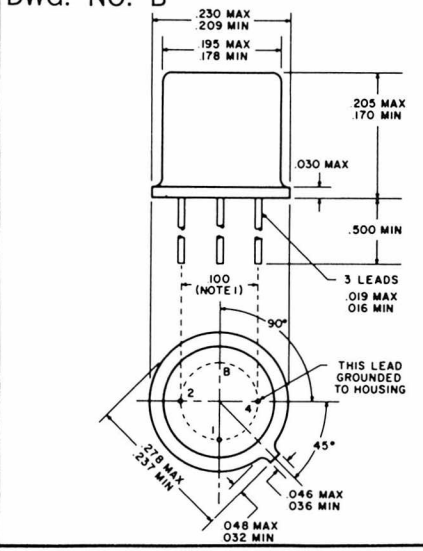
DWG. NO. TO-18

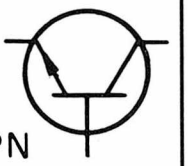
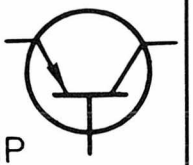
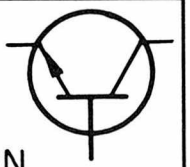
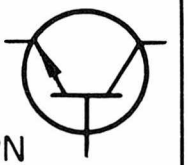


DWG. NO. A



DWG. NO. B



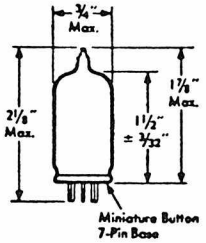
TRANSISTOR TYPE NUMBER	TRANSISTOR TYPE NUMBER	TRANS. DWG. NO.	MANUFACTURER'S NAME	TRANSISTOR SYMBOL
2N337	2N1613	TO-5	GENERAL ELECTRIC	 NPN
2N338	2N1711	TO-5	GENERAL ELECTRIC	
2N1304		TO-5	TEXAS INSTRUMENTS	
2N427	2N428	TO-5	GENERAL ELECTRIC	 PNP
2N395	2N396	TO-5	GENERAL ELECTRIC	
2N404		TO-5	GENERAL ELECTRIC	
2N1305		TO-5	TEXAS INSTRUMENTS	
2N914	2N871	TO-18	GENERAL ELECTRIC	 NPN
2N910	2N911	TO-18	HUGHES	
2N1047	2N1049	A	GENERAL ELECTRIC	 NPN
2N1048	2N1050	A	GENERAL ELECTRIC	
2N2417A	2N2646	B	GENERAL ELECTRIC	
2N2418A	2N2647	B	GENERAL ELECTRIC	
2N2419A		B	GENERAL ELECTRIC	

NOTE:
Blank spaces can be filled in by either teacher or student with additional transistors he may need as reference material.

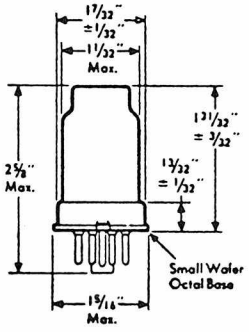
REF. DESIG.	COMPONENT
Q	TRANSISTOR

TUBE DIMENSIONS DWG. NO.

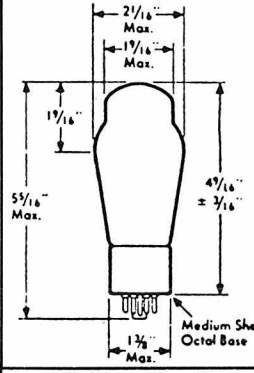
DWG. NO. 1



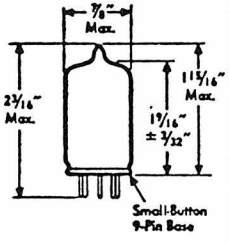
DWG. NO. 2



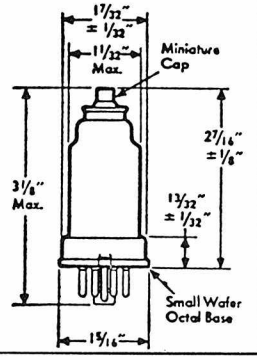
DWG. NO. 3



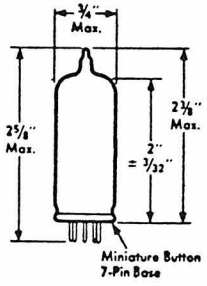
DWG. NO. 4



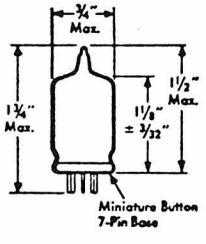
DWG. NO. 5



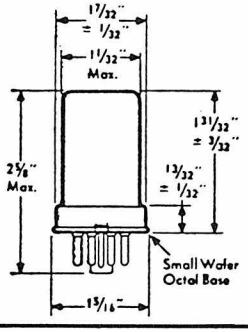
DWG. NO. 6



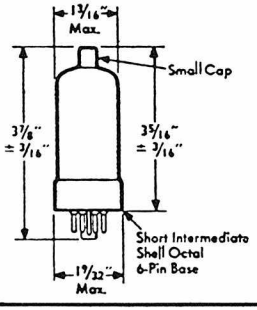
DWG. NO. 7

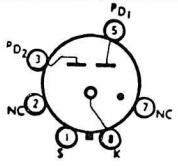
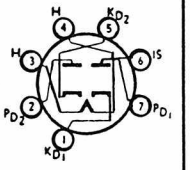
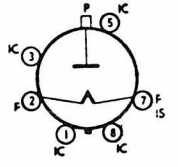
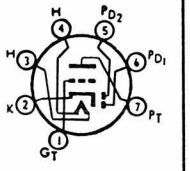
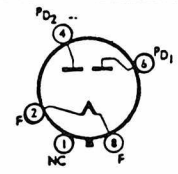
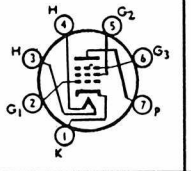
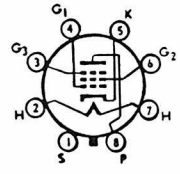
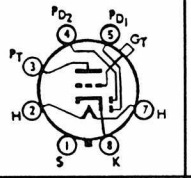
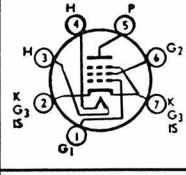
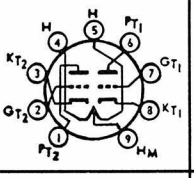
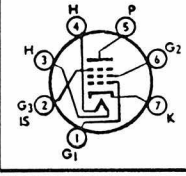
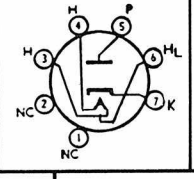


DWG. NO. 8



DWG. NO. 9



TUBE TYPE NUMBER	TUBE SYMBOL	TUBE DIMENSION DWG. NO.	TUBE TYPE NUMBER	TUBE SYMBOL	TUBE DIMENSION DWG. NO.
0Z4		2	6AL5		7
1B3-GT		9	6AQ6 6AT6 6BF6 12AV6		1
5R4-GY 5U4-G		3	6BN6		6
6AB7 6AC7 12SJ7		8	6Q7 6R7		5
6AK5		7	12AX7 12AY7		4
6AK6 6AU6 12BA6		1	35W4		6

PIN CONNECTION MARKING

F — Filament
G — Grid
H — Heater
K — Cathode
NC — No connection
P — Plate or Anode

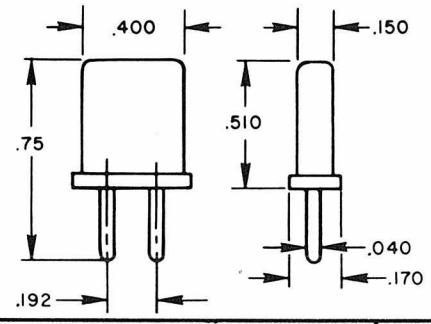
REF. DESIG.
V

COMPONENT
TUBE

MANUFACTURING
WESTINGHOUSE ELECTRIC CORP.

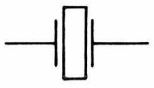
COMPONENT:
RECEIVING CRYSTAL

COMPONENT OUTLINE:



FREQUENCY MEGACYCLES	CRYSTAL NO.
26.510	3647
26.570	3652
26.750	3666

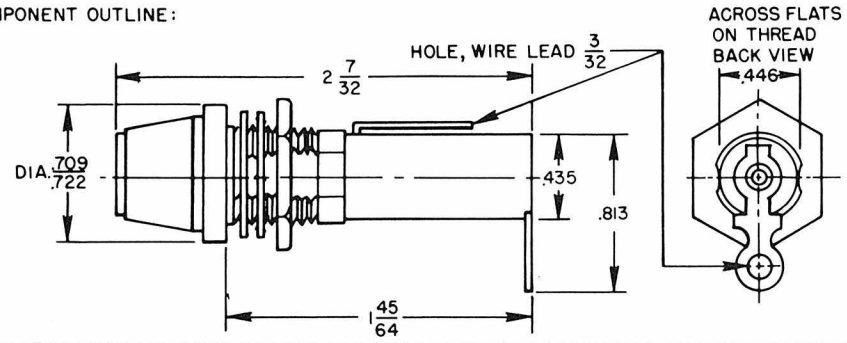
SYMBOL



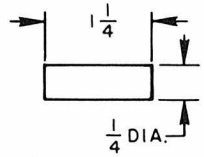
MANUFACTURER	REF. DESIG.	COMPONENT
HERMAN H. SMITH, INC.	Y	CRYSTAL

COMPONENT:
FUSE HOLDER FOR 3AG. HOLDER NO. 342001

COMPONENT OUTLINE:



COMPONENT OUTLINE:



SYMBOL

COMPONENT:
3 AG QUICK ACTING FUSE,
⅛ Amp, 250V NO. 312.125
3 AG "SLO-BLO" FUSE,
½ Amp., 125V NO. 313.500
1 Amp, 125V NO. 313001

MANUFACTURER	REF. DESIG.	COMPONENT
LITTELFUSE, INC.	F	FUSE AND FUSE HOLDER

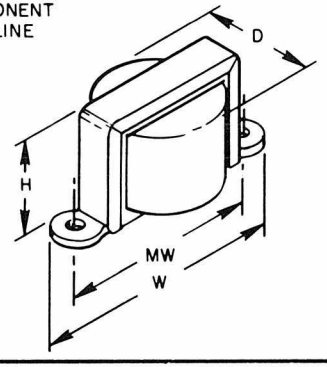
COMPONENT:
AUDIO OUTPUT TRANSFORMER

TYPE NO.	PRIMARY IMPEDANCE	D.C. Ma	AUDIO WATT
S-10X	10000	45	4-6
S-20X	2000	50	2-3
S-40X	14000	5.5	¼

CASE DIMENSIONS

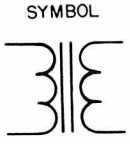
H	W	D	MW
1 11/16	2 11/16	1½	2⅜
1 3/16	2⅛	1¼	1¾
13/16	1⅝	⅞	1⅜

COMPONENT OUTLINE



EXAMPLE; OUTPUT TRANSFORMER,
Primary Impedance — 2000
50 Ma D.C., 2-3 Watt,
NO. of Transformer — S-20X

SYMBOL

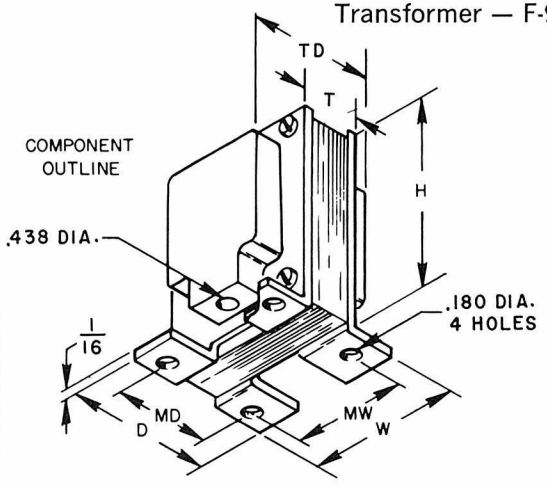


COMPONENT;
LOW VOLTAGE TRANSFORMER, 1 AMP. D.C.
Transformer — F-92A

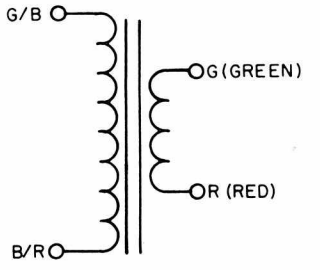
CASE DIMENSIONS

H — 3½	MW — 2
W — 2 31/32	MD — 2¼
D — 3	
T — 1.0	TD — 2¼

COMPONENT OUTLINE

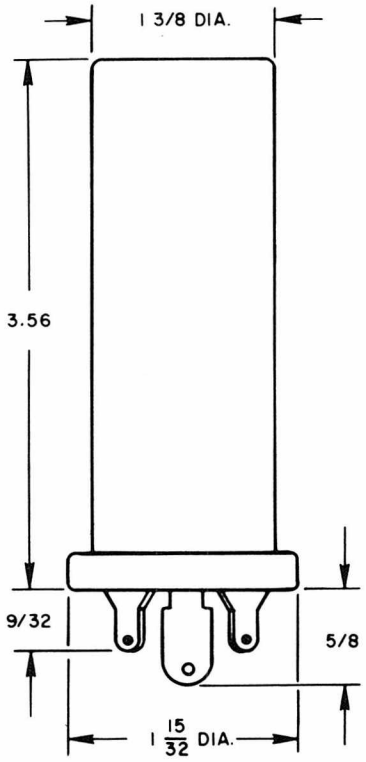


SYMBOL

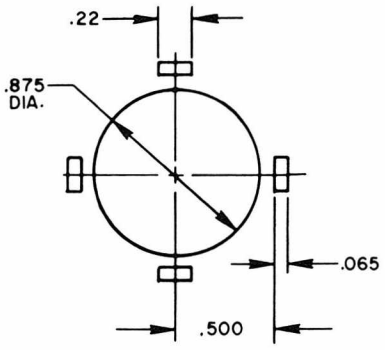


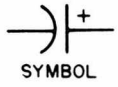
MANUFACTURER	REF. DESIG.	COMPONENT
TRIAD TRANSFORMER CORPORATION	T	TRANSFORMER

COMPONENT OUTLINE



RECOMMENDED CHASSIS CUT OUT

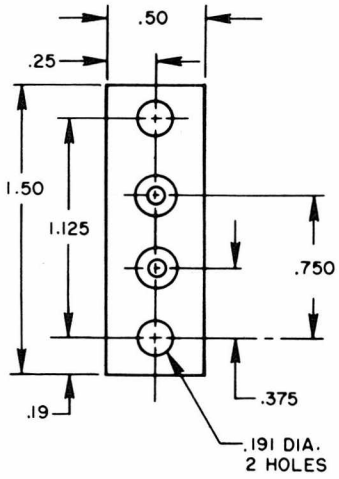


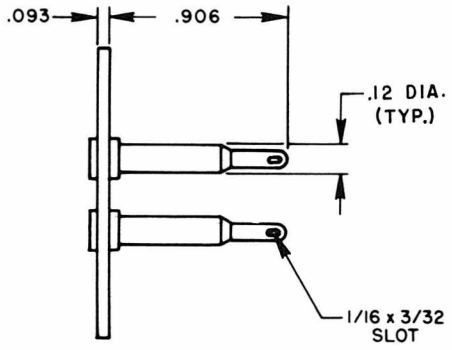


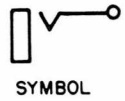
COMPONENT NO. CTM-1284

MANUFACTURER	REF. DESIG.	COMPONENT: 1500 MFD, 50V ELECTROLYTIC CAPACITOR
ARCO ELECTRONIC INC.	C	

COMPONENT OUTLINE





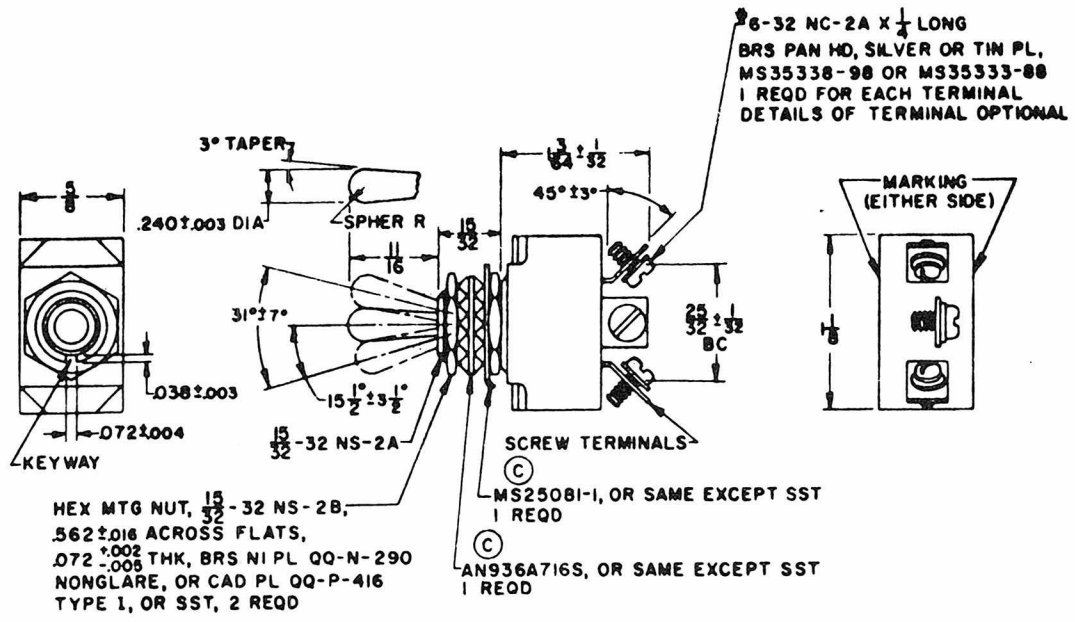


MANUFACTURER	REF. DESIG.	COMPONENT:	COMPONENT NO.
HERMAN H. SMITH, INC.	J	JACK, 2 PINS	1982

COMPONENT:
SWITCHES, TOGGLE
SINGLE POLE

REF. DESIG.
S

FED. SUP CLASS
5930



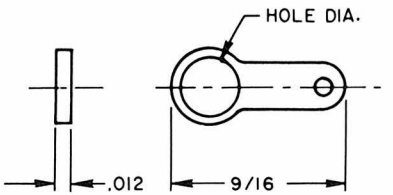
MS PART NO.	FORMER MS PART NO.		FORMER AN PART NO.	FORMER JAN TYPE DESIGNATION	CIRCUIT WITH TOGGLE LEVER IN		
	SCREW-LUG TERMINAL	SOLDER[1]/-LUG TERMINAL			Up position	Center position	Down position (keyway side)
MS35058-21	MS35058-5	—	AN3021-1	ST40E	On	Off	On
	—	MS35058-16	—	ST42E			
MS35058-22	—	—	AN3021-2	ST40A	On	None	Off
	—	MS35058-9	—	ST42A			
MS35058-23	MS35058-4	—	AN3021-3	ST40D	On	None	On
	—	MS35058-15	—	ST42D			
MS35058-24	MS35058-1	—	AN3021-10	—	On	Off	None
	—	MS35058-12	—	—			
MS35058-25	MS35058-3	—	AN3021-12	—	On	Mom off	None
	—	MS35058-14	—	—			
MS35038-26	MS35058-6	—	—	ST40F	On	None	Mom on
	—	MS35058-17	—	ST42F			
MS35058-27	MS35058-7	—	AN3021-7	ST40G	Mom on	Off	Mom on
	—	MS35058-18	—	ST42G			
MS35058-28	MS35058-2	—	AN3021-11	—	None	Off	Mom on
	—	MS35058-13	—	—			
MS35058-29	—	—	AN3021-9	ST40B	On	None	Mom off
	—	MS35058-10	—	ST42B			
MS35058-30	—	—	AN3021-8	ST40C	Off	None	Mom on
	—	MS35058-11	—	ST42C			
MS35058-31	MS35058-8	—	AN3021-6[2]	ST40H	On	Off	Mom on
	—	MS35058-19	—	ST42H			

[1]These MS part numbers are superseded by MS part numbers MS35058-21 to MS35058-31, inclusive, as applicable. By removing the screws and lockwashers from the applicable part, a switch with solder-lug terminals is formed.
[2]With jumper removed.

APPROVED 24 July 1951 REVISED Ⓐ 17 May 1955 Ⓑ 15 April 1958 Ⓒ 20 June 1960

P.A. USAF Other Cust SigC Wep	TITLE SWITCHES, TOGGLE, SINGLE POLE, ONE-HOLE MOUNTING (SEALED TOGGLE BUSHING)	MILITARY STANDARD MS35058
PROCUREMENT SPECIFICATION MIL-S-3950	SUPERSEDES: Air Force — Navy Aeronautical Standard AN3021 dated 12 January 1954	SHEET 1 OF

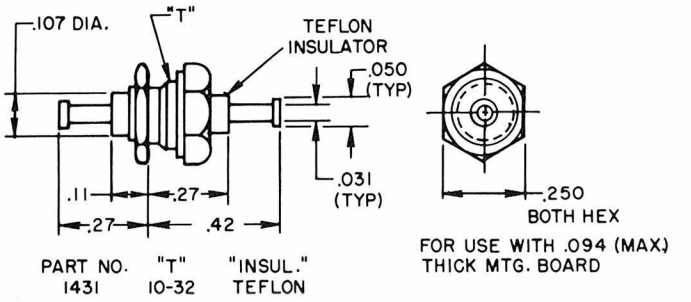
PART NO.	HOLE DIA. FOR SCREW NO.
1488-4	#4
1488-6	#6
1488-8	# 8



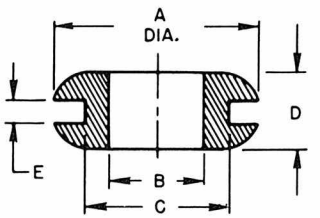
MANUFACTURER
HERMAN H. SMITH INC.

COMPONENT
SOLDER LUG

COMPONENT: INSULATED TERMINAL
PART NO. 1431



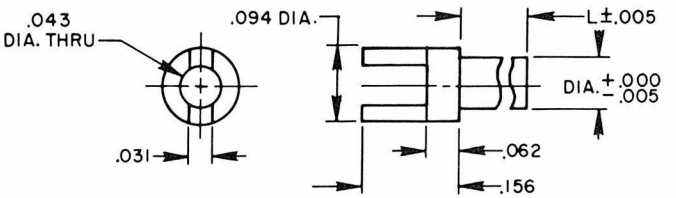
PART NO.	A	B	C	D	E
2185	5/16	1/8	3/16	3/16	1/16
2170	5/8	1/4	3/8	1/4	1/16



MANUFACTURER
HERMAN H. SMITH INC.

COMPONENT
RUBBER GROMMET

COMPONENT: MINIATURE SIZE TERMINALS



PART NO.	DIA.	"L"	RECOMMENDATIONS	
			BOARD THICK	MTG. HOLE
2000 B	.063	.084	.062	+.003
2000 C	.063	.115	.094	.065
2000 D	.063	.147	.125	-.001

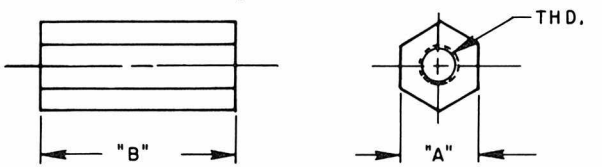
MANUFACTURER
USECO

COMPONENT
TERMINALS

STAND-OFF DIMENSIONS

PART NO.	"A"	"B"	THD.	PART NO.	"A"	"B"	THD.
1551 A	.18	.250	4-40	1551 H	.38	.250	8-32
1551 B	.18	.375	4-40	1551 I	.38	.375	8-32
1551 C	.25	.250	6-32	1551 J	.38	.500	8-32
1551 D	.25	.375	6-32	1551 K	.38	.625	8-32
1551 E	.25	.500	6-32	1551 M	.38	.750	8-32
1551 F	.25	.625	6-32				
1551 G	.25	.750	6-32				

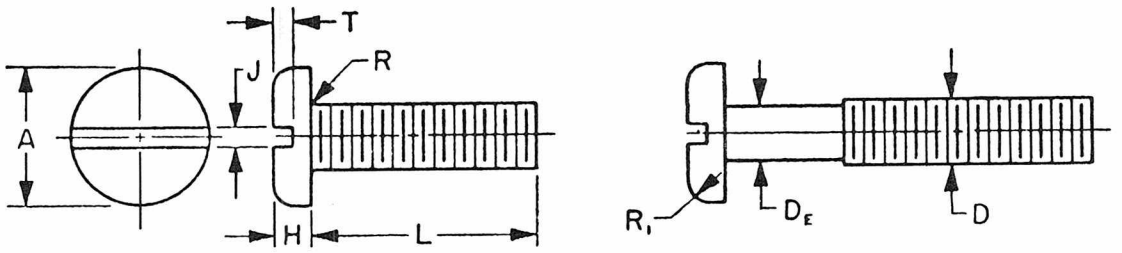
COMPONENT: THREADED, HEX STAND-OFF



MANUFACTURER
USECO

COMPONENT
STAND-OFFS

FED SUP CLASS
5305



Nominal Size	D		2 (.086)	4 (.112)	6 (.138)	8 (.164)
Threads Per Inch			56NC	40NC	32NC	32NC
Body Diameter	D_E	Max	.0860	.1120	.1380	.1640
		Min	.0717	.0925	.1141	.1399
Head Diameter	A	Max	.167	.219	.270	.322
		Min	.155	.205	.256	.306
Head Height	H	Max	.053	.068	.082	.096
		Min	.045	.058	.072	.085
Slot Width	J	Max	.031	.039	.048	.054
		Min	.023	.031	.039	.045
Slot Depth	T	Max	.033	.041	.050	.058
		Min	.023	.030	.038	.043
Radius On Head	R_1	Nom	.035	.042	.046	.052
Radius Under Head	R	Max	.013	.018	.023	.023

Length	L	Tolerance	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN
Threads shall extend to within 2 threads of the bearing surface of the head, or closer if practicable.	1/8	+0 −1/32	1		11	043-6472	24	043-6500	39	043-6528
	3/16		2		12	043-6473	25	019-3254	40	043-6529
	1/4		3		13	043-6474	26	019-3256	41	043-6530
	5/16		4		14	043-6475	27	043-6501	42	043-6531
	3/8		5		15	043-6476	28	043-6502	43	043-6532
	7/16		6		16	043-6477	29	043-6503	44	043-6533
	1/2		7		17	043-6478	30	043-6504	45	043-6534
	5/8		8		18	043-6479	31	043-6505	46	043-6535
	3/4		9		19	043-6480	32	043-6506	47	043-6536
	7/8		10		20	043-6481	33	043-6507	48	043-6537
	1				21	043-6482	34	043-6508	49	043-6538
	1 1/4	+0 −1/16			22	043-6483	35	043-6509	50	043-6539
	1 1/2				23	043-6486	36	043-6510	51	043-6540
	1 3/4						37	043-6511	52	043-6541
	2						38	043-6512	53	043-6542
									54	043-6543
Minimum complete thread length of 1 1/4.	2 1/4	+0 −3/32							55	043-6544
	2 1/2								56	043-6545
	2 3/4								57	043-6546
	3									

Materials: Carbon Steel, Specification QQ-W-409 or QQ-S-633, except Bessemer Compositions; 55,000 PSI minimum ultimate tensile strength.

Finish: Plain (untreated).

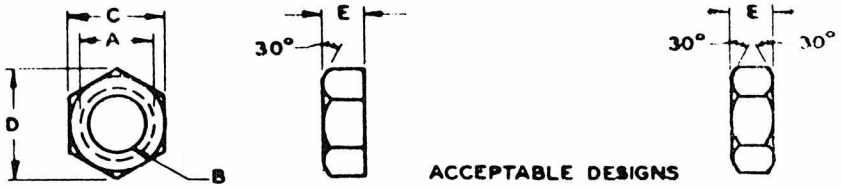
Threads: The threads shall be in accordance with Screw-thread Standards for Federal Services Handbook H-28.

Notes:
(1) Referenced documents of issue in effect on date of invitation for bids shall apply.
(2) In case of conflict with any referenced document, this standard will govern.
(3) The MS part number consists of the MS sheet number, plus the dash number. Example: MS 35221-1.
(4) All dimensions in inches.

APPROVED FEB 9 1954 REVISED

CUSTODIANS	OTHER INT.	MILITARY STANDARD	MS35221
A — ORD N — SHIPS AF — USAF	A — CEMQSIGT N — AMDORSYMC AF —	SCREW, MACHINE, PAN HEAD, SLOTTED, CARBON STEEL, PLAIN FINISH, NC-2A AND UNC-2A	
PROCUREMENT SPECIFICATION FF — S — 92		SUPERSEDES:	SHEET 1 OF 2

FED SUP CLASS 5310



ACCEPTABLE DESIGNS

			No. 2	No. 4	No. 6	No. 8
A	Nominal Size or Basic Major Dia. of Thread		.086	.112	.138	.164
B	Threads per Inch		56	40	32	32
C	Width Across Flats	Nom	3/16	1/4	5/16	11/32
		Max	.1875	.2500	.3125	.3438
		Min	.180	.241	.302	.332
D	Width Across Corners	Max	.217	.289	.361	.397
		Min	.205	.275	.344	.378
E	Thickness	Nom	1/16	3/32	7/64	1/8
		Max	.066	.098	.114	.130
		Min	.057	.087	.102	.117

Material and Protective Coating	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN
Steel, Carbon								
Uncoated	21	019-1716	41	011-4776	61	275-1706	81	275-6800
Cadmium or Zinc Optional	22		42	013-4524	62	013-4530	82	012-0622
Phosphate	23		43	275-9301	63		83	275-9310
Steel, Corrosion Resisting								
Passivated	24	271-4640	44	271-4642	64	271-4644	84	271-4645
Brass								
Uncoated	25		45		65		85	
Tin Plated	26		46		66		86	

			No. 10
A	Nominal Size or Basic Major Dia. of Thread		.190
B	Threads per Inch		24
C	Width Across Flats	Nom	3/8
		Max	.3750
		Min	.362
D	Width Across Corners	Max	.433
		Min	.413
E	Thickness	Nom	1/8
		Max	.130
		Min	.117

Material and Protective Coating	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN
Steel, Carbon								
Uncoated	101	350-3384						
Cadmium or Zinc Optional	102	012-0361						
Phosphate	103	281-5341						
Steel, Corrosion Resisting								
Passivated	104	275-5095						
Brass								
Uncoated	105							
Tin Plated	106							

Material: Steel, Carbon, (Commercial Grade) except Bessemer Steels.
Steel, Corrosion Resisting, Federal Standard No. 66, Steel Numbers: #303, 304, 305, 410, 416, 430.
Brass, Naval, Specification MIL-B-994, Composition A or C.

Protective Coating: Cadmium Plate, Specification QQ-P-416, Type II, Class C.
Zinc Plate, Specification QQ-Z-325, Type II, Class 3.
Phosphate, Specification MIL-C-16232, Type II.
Tin Plate, Specification MIL-T-10727, Type I or II, .0001 thick.

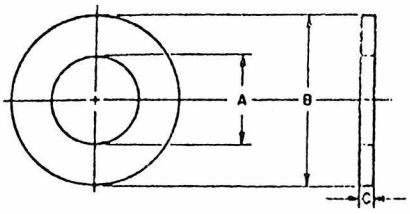
Thread: The threads shall be in accordance with Screw-Thread Standards for Federal Services, Handbook H-28.

Notes:
(1) Referenced documents shall be of the issue in effect on date of invitations for bid.
(2) This document has been promulgated by the Department of Defense as the Military Standard to limit the selection of the item, product or design covered herein in engineering, design and procurement. This standard shall become effective not later than 90 days after the latest date of approval shown.
(3) This standard takes precedence over documents referenced herein.
(4) Nuts shall be free from burrs, scale and all other defects that would affect their serviceability.
(5) The MS part number consists of the MS sheet number, plus the dash number. Example: MS35649-22.
(6) All dimensions in inches.

APPROVED 22 DEC 55 REVISED

CUSTODIANS	OTHER INT.	MILITARY STANDARD	
A — ORD N — SHIPS AF — USAF	A — CESIGT N — MCORY AF —	NUT, PLAIN, HEXAGON, MACHINE SCREW, NC-2B	MS35649
PROCUREMENT SPECIFICATION FF-N-836		SUPERSEDES:	SHEET 1 OF 1

FED SUP CLASS
5310



TOLERANCES

±.010 ON OUTSIDE DIAMETER.
±.005 ON INSIDE DIAMETER UP TO AND INCLUDING #10.
±.010 ON ALL OTHER INSIDE DIAMETERS.
INSIDE AND OUTSIDE DIAMETERS SHALL BE CONCENTRIC WITHIN THE TOLERANCE OF THE INSIDE DIAMETER.

NOM. SIZE	"A" I.D.	"B" O.D.	"C" THICKNESS		CRES		Ni-Cu ALLOY		COPPER		BRASS		ALUMINUM ALLOY	
			Max.	Min.	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN
0	.078	.187	.025	.016	301		401		501		601		701	
2	.093	.250	.025	.016	302		402		502		602		702	
4	.125	.250	.028	.017	303		403		503		603		703	
4	.125	.312	.040	.025	304		404		504		604		704	
6	.156	.312	.048	.027	305		405		505		605		705	
6	.156	.375	.065	.036	306		406		506		606		706	
8	.187	.375	.065	.036	307		407		507		607		707	
10	.218	.437	.065	.036	308		408		508		608		708	
10	.250	.562	.080	.051	309		409		509		609		709	
1/4	.281	.625	.080	.051	310		410		510		610		710	
1/4	.312	.750	.080	.051	311		411		511		611		711	
5/16	.343	.687	.080	.051	312		412		512		612		712	
5/16	.375	.875	.104	.064	313		413		513		613		713	
3/8	.406	.812	.080	.051	314		414		514		614		714	
3/8	.437	1.000	.104	.064	315		415		515		615		715	
7/16	.468	.921	.080	.051	316		416		516		616		716	
7/16	.500	1.250	.104	.064	317		417		517		617		717	
1/2	.531	1.062	.121	.074	318		418		518		618		718	
1/2	.562	1.375	.132	.086	319		419		519		619		719	
5/8	.656	1.312	.121	.074	320		420		520		620		720	
5/8	.687	1.750	.160	.108	321		421		521		621		721	
3/4	.812	1.500	.160	.108	322		422		522		622		722	
3/4	.812	2.000	.177	.122	323		423		523		623		723	
7/8	.937	1.750	.160	.108	324		424		524		624		724	
7/8	.937	2.250	.192	.136	325		425		525		625		725	
1	1.062	2.000	.160	.108	326		426		526		626		726	
1	1.062	2.500	.192	.136	327		427		427		627		727	
1 1/8	1.250	2.750	.192	.136	328		428		528		628		728	
1 1/4	1.375	3.000	.192	.136	329		429		529		629		729	
1 3/8	1.500	3.250	.213	.153	330		430		530		630		730	
1 1/2	1.625	3.500	.213	.153	331		431		531		631		731	
1 5/8	1.750	3.750	.213	.153	332		432		532		632		732	
1 3/4	1.875	4.000	.213	.153	333		433		533		633		733	
1 7/8	2.000	4.250	.213	.153	334		434		534		634		734	
2	2.125	4.500	.213	.153	335		435		535		635		735	
2 1/4	2.375	4.750	.248	.193	336		436		536		636		736	
2 1/2	2.625	5.000	.280	.210	337		437		537		637		737	
2 3/4	2.875	5.250	.310	.228	338		438		538		638		738	
3	3.125	5.500	.327	.249	339		439		539		639		739	

All dimensions are in inches.

MATERIALS: Steel, Corrosion Resisting; QQ-S-765, 60,000 psi minimum tensile strength, 1% minimum elongation in 2 inches.
Nickel — Copper Alloy (Monel); QQ-N-281, Class A
Copper; QQ-C-576
Brass, Half Hard, QQ-B-611, Composition C
Aluminum Alloy, Half Hard; QQ-A-359

PROTECTIVE COATINGS:
Corrosion Resisting Steel Washers shall be passivated.
Aluminum Alloy Washers shall be anodized in accordance with MIL-A-8625 or given a chemical film in accordance with MIL-C-5541.

IDENTIFICATION NUMBER — (MS Number) — (Washer Dash No.)
Example: MS 15795 — 318 would be the identification number of a ½ nominal size corrosion resisting steel washer with a 1.062 outside diameter.

NOTES: 1. In case of conflict with any referenced document this standard will govern.
2. Referenced documents shall be the issue in effect on the date at invitation for bids.

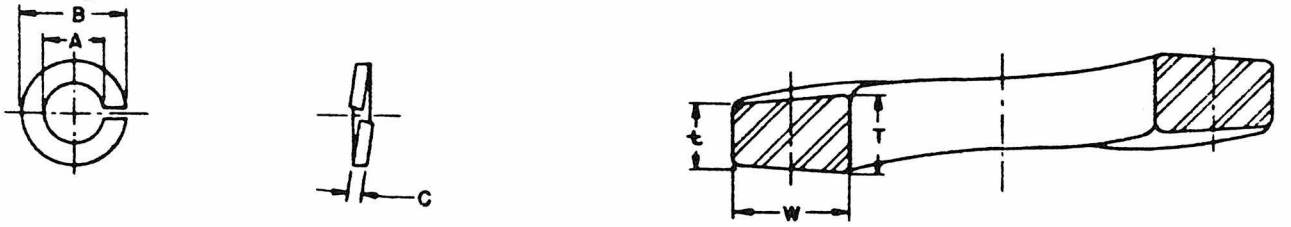
APPROVED 2 June 1954 REVISED

CUSTODIANS	OTHER INT.	MILITARY STANDARD	
Ord	A — CESIGT		
NOrd	N — ASHYMC	WASHERS, FLAT, METAL, ROUND, GENERAL PURPOSE	MS15795
USAF	AF —		
PROCUREMENT SPECIFICATION NONE		SUPERSEDES:	SHEET 2 OF 2

MILITARY STANDARD

WASHER, LOCK, SPLIT, HELICAL, LIGHT SERIES

MS35337



NOMINAL SIZE	INSIDE DIAMETER — A —		WIDTH — W —	THICKNESS — C — $\frac{T+t}{2}$		OUTSIDE DIAMETER — B —	STEEL								CORROSION RESISTING		PHOSPHOR BRONZE	
							PLAIN (UNCOATED)		CADMIUM OR ZINC OPTIONAL		CADMIUM		PHOSPHATE		PASSIVATED		CADMIUM	
	MAX.	MIN.	MIN.	MAX.	MIN.	MAX.	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN	Dash No.	FIIN
#2 .086	.097	.088	.030	.021	.015	.165	1	019-2298	20		39		58	019-2303	77	058-2950	96	
#4 .112	.124	.115	.035	.026	.020	.202	2	011-8871	21		40		59	013-1195	78	058-2949	97	
#6 .138	.151	.141	.040	.031	.025	.239	3	011-8872	22		41		60	013-1196	79	043-1754	98	
#8 .164	.178	.168	.047	.037	.031	.280	4	011-8869	23		42		61	013-1197	80	042-9067	99	
#10 .190	.205	.194	.055	.046	.040	.323	5	011-8873	24		43		62	274-8708	81	058-2951	100	
¼	.267	.255	.107	.057	.047	.489	6	011-3114	25		44		63	274-8714	82	043-5862	101	
5/16	.333	.319	.117	.066	.056	.575	7	011-2723	26		45		64	013-1201	83		102	
⅜	.398	.382	.136	.080	.070	.678	8	011-0730	27		46		65	274-8719	84		103	
7/16	.464	.446	.154	.095	.085	.780	9	011-0405	28		47		66	012-1739	85		104	
½	.529	.509	.170	.109	.099	.877	10	010-6500	29		48		67	013-1203	86		105	261-7125
9/16	.595	.573	.186	.123	.113	.975	11	011-2724	30		49		68		87		106	
⅝	.660	.636	.201	.136	.126	1.082	12	010-3334	31		50		69	012-3167	88		107	189-6811
¾	.791	.763	.233	.163	.153	1.277	13	010-3335	32		51		70	013-1226	89		108	
⅞	.922	.890	.264	.199	.179	1.470	14	010-3336	33		52		71	013-1227	90		109	
1	1.053	1.017	.289	.222	.202	1.656	15	011-7661	34		53		72		91		110	
1⅛	1.184	1.144	.314	.244	.224	1.837	16	187-3202	35		54		73	013-1229	92		111	
1¼	1.315	1.271	.336	.264	.244	2.012	17	011-7613	36		55		74		93		112	
1⅜	1.446	1.398	.356	.284	.264	2.183	18	011-8028	37		56		75		94		113	
1½	1.577	1.525	.375	.302	.282	2.352	19	011-8029	38		57		76		95		114	

Material: Steel, Carbon, FS1060 to FS1080, Rockwell "C" 45-53, Specification QQ-S-633.
Corrosion Resisting Steel, Federal Standard No. 66, Steel Numbers 302 Rockwell "C" 35-43 or 420 Rockwell "C" 43-53.
Phosphor Bronze, Specification QQ-B-746, Composition A, Hard.

Protective Coating:
Cadmium Plate, Specification QQ-P-416, Type II, Class C.
Zinc Plate, Specification QQ-Z-325, Type II, Class 3.
Phosphate, Specification MIL-C-16232, Type II.

Dimensions: All dimensions are in inches unless otherwise specified.
Part Numbers: The MS part number consists of the MS number, plus the dash number. Example: MS35337-1.
Notes: (1) Referenced documents shall be of the issue in effect on invitations for bid.
(2) This standard takes precedence over documents referenced herein.
(3) This document has been promulgated by the Department of Defense as the Military Standard to limit the selection of the item, product or design covered herein in engineering, design and procurement. This standard shall become effective not later than 90 days after the latest date of approval shown.

APPROVED MAR 4 1954 REVISED 28 APRIL 56

FED SUP CLASS 5310

SCREW CLEARANCE AND HOLE CHART

SCREW NO.	SCREW BODY DIA.	SINGLE HOLE DIA.	MIN. 82°	CSK. SHT. THICKNESS 100°	CSK. DIA. ±.005
2	.086	.089 (#43)	.063		.151
4	.112	.120 (#31)	.083	.064	.225
6	.138	.144 (#27)	.095	.072	.289
8	.164	.172 (11/64)	.109	.081	.337
10	.190	.194 (#11)	.125	.091	.390
1/4	.250	.257 (F)	.168	.125	.512
5/16	.313	.316 (O)	.209	.156	.640
3/8	.375	.386 (W)	.253	.188	.767
7/16	.438	.453 (29/64)	.241	.204	.895
1/2	.500	.516 (33/64)	.241	.231	1.002
9/16	.563	.578 (37/64)	.271	.251	1.150
5/8	.625	.641 (41/64)	.312	.286	1.277

FOR MULTIPLE HOLE PATTERN USE THE FOLLOWING FORMULAS:*

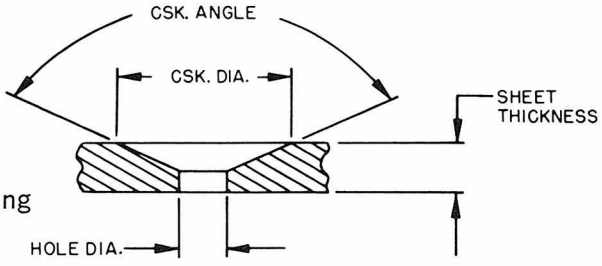
FOR CLEARANCE HOLE ON TAPPED ONLY

2 HOLE PATTERN $D = d + 2t$
3 HOLE PATTERN $D = d + 4t$
4 HOLE PATTERN $D = d + 2.82t$
6 HOLE PATTERN OR MORE THAN 6 HOLES. $D = d + 5.62t$

WHERE D = CLEARANCE HOLE DIA.
d = SCREW BODY DIA.
t = TOLERANCE (℄ to ℄ HOLE)

FOR CLEARANCE HOLE ON CLEARANCE HOLE DIVIDE THE LAST PART BY 2

$\frac{2t}{2}$, $\frac{4t}{2}$ etc.



EXAMPLE:

1. What is the hole Dia. for a single #6-32 Binding Head Screw?

   ANSWER: $.144 \begin{smallmatrix}+.005\\-.001\end{smallmatrix}$ DIA.

2. What is the hole Dia. for a single #4-40 82° Flat Head Screw?

   ANSWER: $.120 \begin{smallmatrix}+.004\\-.001\end{smallmatrix}$ DIA. HOLE
   CSINK .225 DIA. x 82°

3. What hole Dia. should be drilled for a #4-40 Binding Head Screw, 4 Places, (Tolerance between holes ℄ to ℄ is ±.005)

   ANSWER; $D = d + 2.82t$
   $D = .112 + (2.82 \times .005)$
   $D = .112 + .0141 = .1261$

   Therefore Hole Dia. should read to the largest Drill Size (See Appendix E)

   $.128 \begin{smallmatrix}+.005\\-.001\end{smallmatrix}$ DIA.
   4 HOLES

STANDARD DRILLED HOLE TOLERANCES	
HOLE DIA.	TOLERANCE
.0135 THRU .125	$\begin{smallmatrix}+.004\\-.001\end{smallmatrix}$
.126 THRU .250	$\begin{smallmatrix}+.005\\-.001\end{smallmatrix}$
.251 THRU .500	$\begin{smallmatrix}+.006\\-.001\end{smallmatrix}$
.501 THRU .750	$\begin{smallmatrix}+.008\\-.001\end{smallmatrix}$
.751 THRU 1.000	$\begin{smallmatrix}+.010\\-.001\end{smallmatrix}$
1.001 THRU 2.000	$\begin{smallmatrix}+.012\\-.001\end{smallmatrix}$

*For exercises see Lesson NO. 1 "MECHANICAL DRAFTING REVIEW."

FRACTIONS AND DECIMAL EQUIVALENTS

1/64	.0156	33/64	.5156
1/32	.0312	17/32	.5312
3/64	.0468	35/64	.5468
1/16	.0625	9/16	.5625
5/64	.0781	37/64	.5781
3/32	.0937	19/32	.5937
7/64	.1093	39/64	.6093
1/8	.125	5/8	.625
9/64	.1406	41/64	.6406
5/32	.1562	21/32	.6562
11/64	.1718	43/64	.6718
3/16	.1875	11/16	.6875
13/64	.2031	45/64	.7031
7/32	.2187	23/32	.7187
15/64	.2343	47/64	.7343
1/4	.25	3/4	.75
17/64	.2656	49/64	.7656
9/32	.2812	25/32	.7812
19/64	.2968	51/64	.7968
5/16	.3125	13/16	.8125
21/64	.3281	53/64	.8281
11/32	.3437	27/32	.8437
23/64	.3593	55/64	.8593
3/8	.375	7/8	.875
25/64	.3906	57/64	.8906
13/32	.4062	29/32	.9062
27/64	.4218	59/64	.9218
7/16	.4375	15/16	.9375
29/64	.4531	61/64	.9531
15/32	.4687	31/32	.9687
31/64	.4843	63/64	.9843
1/2	.5	1	1.

OHM'S LAW

VOLTS(E)	OHMS(R)	AMPERES(I)	WATTS(W)
$E = IR$	$R = E/I$	$I = E/R$	$W = EI$
$E = \sqrt{WR}$	$R = E^2/W$	$I = W/E$	$W = I^2R$
$E = W/I$	$R = W/I^2$	$I = \sqrt{W/R}$	$W = E^2R$

DRILL SIZES — DECIMAL EQUIVALENTS

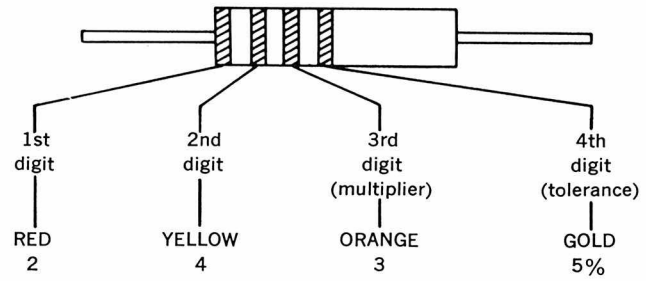
Drill Size	Decimal Equivalent	Drill Size	Decimal Equivalent	Drill Size	Decimal Equivalent
80	.0135	1/8	.1250	O	.3160
79	.0145	30	.1285	P	.3230
1/64	.0156	29	.1360	21/64	.3281
78	.0160	28	.1405	Q	.3320
77	.0180	9/64	.1406	R	.3390
76	.0200	27	.1440	11/32	.3437
75	.0210	26	.1470	S	.3480
74	.0225	25	.1495	T	.3580
73	.0240	24	.1520	23/64	.3594
72	.0250	23	.1540	U	.3680
71	.0260	5/32	.1562	3/8	.3750
70	.0280	22	.1570	V	.3770
69	.0292	21	.1590	W	.3860
68	.0310	20	.1610	25/64	.3906
1/32	.0313	19	.1660	X	.3970
67	.0320	18	.1695	Y	.4040
66	.0330	11/64	.1719	13/32	.4062
65	.0350	17	.1730	Z	.4130
64	.0360	16	.1770	27/64	.4219
63	.0370	15	.1800	7/16	.4375
62	.0380	14	.1820	29/64	.4531
61	.0390	13	.1850	15/32	.4687
60	.0400	3/16	.1875	31/64	.4843
59	.0410	12	.1890	1/2	.5000
58	.0420	11	.1910	33/64	.5156
57	.0430	10	.1935	17/32	.5313
56	.0465	9	.1960	35/64	.5469
3/64	.0469	8	.1990	9/16	.5625
55	.0520	7	.2010	37/64	.5781
54	.0550	13/64	.2031	19/32	.5937
53	.0595	6	.2040	39/64	.6094
1/16	.0625	5	.2055	5/8	.6250
52	.0635	4	.2090	41/64	.6406
51	.0670	3	.2130	21/32	.6562
50	.0700	7/32	.2187	43/64	.6719
49	.0730	2	.2210	11/16	.6875
48	.0760	1	.2280	45/64	.7031
5/64	.0781	A	.2340	23/32	.7187
47	.0785	15/64	.2344	47/64	.7344
46	.0810	B	.2380	3/4	.7500
45	.0820	C	.2420	49/64	.7656
44	.0860	D	.2460	25/32	.7812
43	.0890	1/4E	.2500	51/64	.7969
42	.0935	F	.2570	13/16	.8125
3/32	.0937	G	.2610	53/64	.8281
41	.0960	17/64	.2656	27/32	.8437
40	.0980	H	.2660	55/64	.8594
39	.0995	I	.2720	7/8	.8750
38	.1015	J	.2770	57/64	.8906
37	.1040	K	.2811	29/32	.9062
36	.1065	9/32	.2812	59/64	.9219
7/64	.1093	L	.2900	15/16	.9375
35	.1100	M	.2950	61/64	.9531
34	.1110	19/64	.2968	31/32	.9687
33	.1130	N	.3020	63/64	.9844
32	.1160	5/16	.3125	1	1.0000
31	.1200				

COLOR CODE

COLOR	ABBREV.*	NO.	MULTIPLIER	TOL. ±%
BLACK	(BLK) BK	0		
BROWN	(BRN) BR	1	10	
RED	(RED) R	2	100	
ORANGE	(ORN) O	3	1000	
YELLOW	(YEL) Y	4	10^4	CATHODE
GREEN	(GRN) GN	5	10^5	
BLUE	(BLU) BL	6	10^6	ANODE
VIOLET OR PURPLE	(VIO) V (PR) P	7	10^7	
GRAY	(GY) GY	8	10^8	
WHITE	(WHT) W	9	10^9	
GOLD				5%
SILVER				10%
NO COLOR				20%

*ABBREVIATIONS shown in brackets are MILITARY STANDARDS.
*ABBREVIATIONS not shown in brackets were made up specifically for this exercise book.

EXAMPLE: Resistor value by COLOR



Answer; 24000 or 24K, ±5%

(K = 1000, M = 1000000)